ANNALS

OF

The Entomological Society of America

VOLUME XXXII, 1939

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MAILING DATES FOR 1939 ISSUE OF ANNALS

March Number—March 20, 1939.
June Number—June 30, 1939.
September Number—September 20, 1939.
December Number—December 16, 1939.

379537

Volume XXXII Number 1

ANNALS

OF

The Entomological Society of America

MARCH, 1939

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PUBLISHED QUARTERLY BY THE SOCIETY
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Entered as second-class matter April 11, 1908, at the Post Office at Columbus, Ohio, under the act of Congress of March 3, 1879.

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ANNALS
OF
The Entomological Society of America

Volume XXXII MARCH, 1939 No. 1

THE MUSCLES OF THE LEPIDOPTEROUS MALE GENITALIA

Wm. T. M. Forbes,
Cornell University,
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It is a commonplace in comparative morphology that the muscles and their nerves give fundamental data, comparable with that given by the skeletal parts. There have been many attempts to allocate the male genitalia of the Lepidoptera to their proper segments and appendages, but so far with very uncertain results. The chitinous parts have been fully studied, and the results summarized from time to time, especially by Pierce in his introductions to the "Genitalia of the British Noctuidae" and "Geometridae." But the internal parts have been less completely recorded. The embryology is hopelessly distorted by the fact that the whole group of appendages are formed very late from an imaginal bud; the nerves give uncertain evidence, because all of them are branches of a single trunk, passing back from the fused terminal ganglia; the muscles have been only partially and I suspect inaccurately reported, and the two forms cited by Snodgrass in his "Principles of Insect Morphology" are further degenerate types, Bombyx having largely lost the clasper and much of the vinculum, and having no recognizable distinction of juxta and valve; Carpocapsa being less reduced in having preserved the juxta as a separate sclerite, but also completely lacking uncus and clasper.

The present paper reports the structure of *Septis arctica*, a typical member of the trifid Noctuidae, with some notes on other Macroheterocera. The Noctuidae lack the gnathos;—this is well developed in the Geometridae, but has no muscles, and is also figured as without muscles in Bombyx, by Snodgrass. But the Noctuidae have the advantage of showing a fully functional

clasper, and are remarkable in possessing a well developed ninth pleurite, which is movably articulated to both tergite (tegumen) and sternite (vinculum), and also takes part in the articulation of the valve.

In the Lepidoptera the male genitalia may be considered to include only the ninth and following segments, though the muscles of the eighth segment support them and will be listed as *extrinsic* muscles. Of the latter I find only 5 pairs, all running from the anterior part of the segment to the chitinized ring (tegumen, pleurite and vinculum) of the ninth segment. There are two tergal muscles (figs. 1, 2) T1 from near the lateral edge of the 8th antecosta to the front edge of the tegumen mid-dorsally, and T2 from almost the same point, inserting by a long tendon at the extreme upper posterior angle of the vinculum, where it is emarginate to receive the pleura. The sternal muscles are three, all attached in a group to the anterior lateral angle of the sternite: S1 is small and short, and inserts in the under side of the saccus, just posterior to the origin of the large retractor of the aedoeagus; S2 short and massive, inserting in the lower end of the vinculum at its exact articulation with the lower edge of the valve; and S3 long and slender, running up to attach to the lower end of the anterior stiffened edge of the pleurite. T2 and S3 cross each other near their insertions, and in the normal positions of the parts the tendon of T2 makes a short loop about S3. These five muscles are all partly exposed through the thin intersegmental membrane connecting the ring with the 8th segment, and can be most easily exposed by cutting the side of the 7th and 8th segments and reflecting the flaps, leaving the genitalia proper untouched.

There are eight pairs of muscles in the genitalia proper and end of the body, besides a slender fibre from the side of the juxta to the clasper, which is absent in *S. arctica*, and the internal muscles of the aedoeagus, which will not be considered. They will be listed in order from dorsum to venter.

1. *Depressor of uncus.*—A massive muscle with its origin on the posterior edge of the tegumen proper just where it joins the penicillus, to the swollen base of the uncus. It is enclosed in the chitinous sheath of the tegumen except from the inner anterior side, where all but the ends is exposed. In Trifid Noctuidae the uncus is ankylosed with the tegumen and the muscle doubtless serves to raise and draw in the penicillus.

2. *Retractor of anal tube.*—This originates on the anterior edge of the tegumen, loops about muscle 1, and inserts in a large fiber on the

chitinized subanal plate, and several finer ones on the membranous side of the anal tube. It will retract and raise the anal tube, but may perhaps have originally been a muscle of the gnathos.

3. A slender muscle, originating from the same suture of penicillus and tegumen as 1, but more dorsally and on the opposite face, running directly under the articulation of tegumen and pleura and over the nerve to the penicillus, to insert in the tip of the ental extension of the valve (tendon) just where it articulates with the transtilla. This muscle would appear to be morphologically an extensor of the valve, but in the Noctuid it probably serves as a depressor of the penicillus, the valve having a much more massive muscle of its own (4).

4. *The extensor of the valve.*—This is a massive muscle originating on the anterior edge of the 9th pleurite and inserting in the "tendon" of the valve lateral to No. 3. It is represented rather diagrammatically in the figures, in fact it is much more massive and the fibres take an irregular spiral course, which I am unable either to describe or figure with any clearness.

5. The *flexor of the clasper.*—This is a massive muscle, found in every member examined of the Lepidoptera which has a functional valve. In *S. arctica* it originates in the swollen saccular portion of the valve, mostly along the posterior edge as shown, but also partly from the external and ental faces, and inserts into the sclerite which bears the minute clasper. In forms where the clasper is fully functional it is attached to the clasper itself; in *Plusia precationis* the origin is more dorsal, lying mostly ental to muscle 8, and in a few Quadrifidae a slip actually originates in the juxta. In such forms it helps muscle 8 as a flexor of the valve. It certainly has that function where the clasper has been completely fused with the valve, as in Telea and Bombyx.

6. *Protractor of aedoeagus.*—This is a massive muscle in all forms examined, and originates in the whole anterior edge of the vinculum from its dorsal articulation almost to the midventral line; and inserts in the extreme base of the aedoeagus, almost completely enwrapping it. It is even stouter than figured. In the lateral view the aedoeagus has been raised above its normal position, and in the dorsal view drawn to the left to make the relation clearer.

7. *Retractor of aedoeagus.*—The antagonist of the preceding, lying ental to it, and equally massive. It takes its origin from the tip of the saccus, enwrapping it on both sides, runs up around the aedoeagus on each side and inserts on the dorsal side of the aedoeagus just in front of the attachment of the vas deferens. These two muscles are universally present in the forms studied; but those Microlepidoptera in which the aedoeagus articulates with the saccus will probably show modifications. They are 5 and 3 of Snodgrass's fig. 308 D.

8. *Flexor of valve.*—This also is present in all forms with a functional juxta, but is buried so deep that it is easily overlooked. Its origin is on the inner face of the juxta, on the lower half in the Noctuidae, but in the upper portion in the Tortricids (Snodgrass, fig. 308 I), and it inserts in the extreme base of the valve, mesal to muscle 5. The best

way to uncover it is to separate the genitalia proper from the 8th segment, pin them dorsal side up with the valves widely opened, and then dissect off the aedoeagus by cutting the muscles 6 and 7 away from their attachments to the vinculum (saccus). The juxta then occupies the middle of the field (fig. 1 A), and the tips of the two sacculi almost meet each other ventrally within the loop of the vinculum. In this position the two muscles 8 run longitudinally and parallel from the juxta to the tips of the sacculi.

Articulations.—The various parts of the genitalia work on each other in *S. arctica* as follows: The genitalia as a whole connect to the body with a wide articular membrane; the uncus is completely ankylosed with the tegumen, leaving only a fine faint suture, a little basad of the apparent uncus; the articulations of the pleurite with both tegumen and vinculum are movable, but the surfaces overlap so much that the movement is not large, in fact the whole lower half of the pleurite overlaps a plate of the vinculum. There is also a fine thread from the lower end of the penicillus, winding spirally around the pleurite on the inner side and attached to the tip of the vinculum. The penicillus is only partly chitinized and very flexible, but without any formed articulation. Each half of the transtilla is regularly articulated to the tip of the ental extension (Tendon) of the valve, but the two halves only connect over the tip of the aedoeagus with a fold of somewhat thickened and roughened membrane. The chitinized ventral plate of the anal tube has two lateral extensions which nearly reach the uncus, but not

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EXPLANATION OF FIGURES 1-2

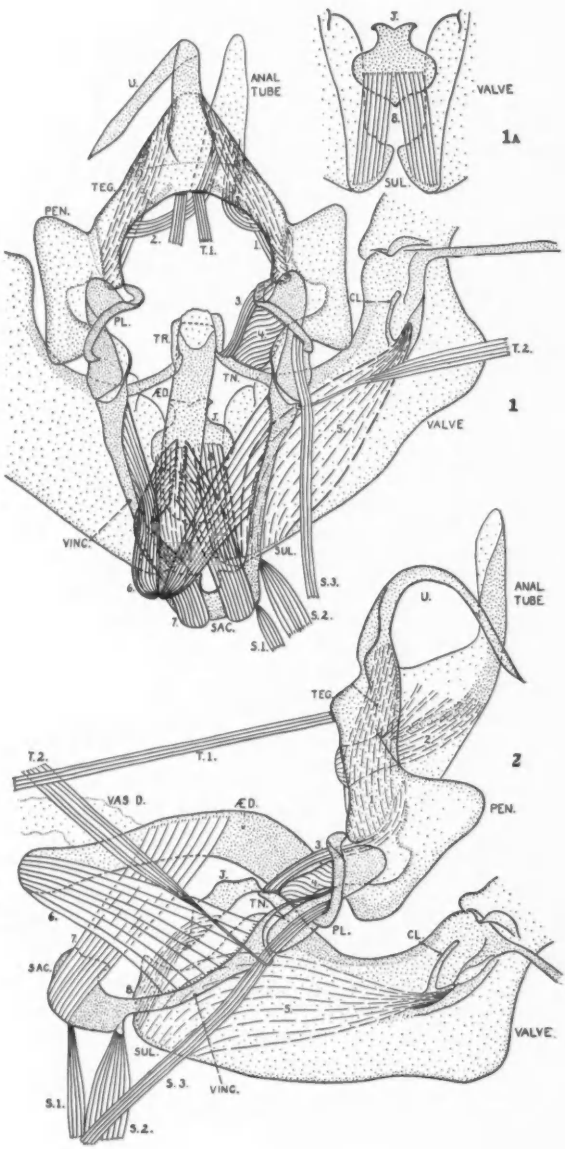
In the figures edges of sclerites are represented by strong lines, muscles by parallel striation, solid if exposed or covered only by membrane, broken if covered by sclerites or other muscles. Independent membrane is not indicated, membranous portions of sclerites more lightly stippled in figs. 1 and 2.

A 8, 9, 10, 12—Abdominal segments.
Æd.—Ædoeagus.
Cl.—Clasper.
J.—Juxta.
Pen.—Penicillus (sensory lobe of tegumen).
Pl.—Pleurite of 9th segment.
S. 1, 2, 3—Extrinsic muscles arising on 8th sternum.
Sac.—Saccus (ental extension of vinculum).
Sul.—Sacculus (ventral articular part of valve).
T. 1, 2—Extrinsic muscles arising on 8th tergum.
Teg.—Tegumen.
Tn.—Tendon (ental extension of costa of valve).
Tr.—Transtilla.
U.—Uncus.
V.—Valve.
Vas D.—Terminal portion of membranous vas deferens.
Vinc.—Vinculum.

Fig. 1. *Septis arctica.* Dorso-anterior view with valves opened. Anal tube and aedoeagus drawn aside to show relations of muscles.

Fig. 1a. Detail with aedoeagus and its muscles removed to show attachment of muscle 8.

Fig. 2. Lateral view with left valve removed. The muscles are indicated in the order of superposition that those of the left side would show, except muscle 5.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quite. The valves have a complicated articulation between the costa and pleura in which the vinculum is also involved, and a loose ventral one with the vinculum just above the saccus, but in between have only a sliding connection of loose membrane. The juxta has a loose articulation with the inner edge of the valve, but otherwise merely hangs in membrane. The aedoeagus merely slides through the space between the transtilla and juxta, being guided by a groove in the inner face of the latter; but has no tight connection and no muscular bonds with any of the adjacent structures.

Cirphis pseudargyrea was partially studied. In this form evidently a much larger part of the tegumen has been modified into a penicillus, so that muscle 1 runs mainly within the penicillus rather than the tegumen proper.

Geometridae.—A geometrid was chosen as representative of a distinct superfamily, and a form in which the gnathos is well developed. Most of the muscles were recognized, but there are the following divergences. The uncus is slightly movable, while there is no penicillus, so muscle 1 functions as a depressor of the uncus. The gnathos articulates movably with the uncus but has no muscles of its own. Apparently muscle 2, to the anal tube, indirectly moves it. The pleurite is ankylosed to the tegumen, but has a suture, and muscle 4 runs to it just as in the Noctuid; its articulation to the vinculum is movable; in the absence of the penicillus muscle 3 runs from the lower inner face of the tegumen. Muscle 5 has only a slip originating on the sacculus, but a massive connection with the juxta, so doubtless it serves primarily to draw the enormous juxta up against the valve, there being no functional clasper.

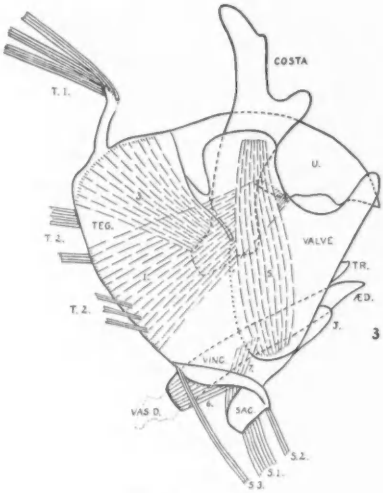
Bombyx mori (Snodgrass, Principles of Insect Morphology, p. 603, figs. 308 A-F). The silkworm moth is an aberrant and degenerate form, representing a different main line of development from the Noctuidae. The tegumen is massive, with strong and movable uncus and gnathos (as also in the Geometridae and Sphingidae); but the vinculum is vestigial on the sides, being developed mainly as a saccus. The valves and juxta are completely fused, without even a suture so far as I can see, and there is nothing to represent the clasper. The muscles, as figured by Snodgrass, cannot be completely homologized with those of Septis. Of the extrinsic muscles, I strongly suspect 4 is my T. 1, though I have never seen a form in which it attached to the aedoeagus; 2 and 1, are obviously my S. 1. and S. 2. Of the intrinsic muscles, 5 and 3 are no doubt my 6 and 7, the former having switched ts origin to the juxta as a result of the loss of the lateral part of the

EXPLANATION OF FIGURES 3–5

Fig. 3. *Telea polyphemus*, left side. Muscles shown as if seen by transparency.

Fig. 4. *Argynnis aphrodite*. Muscles figured as in fig. 2 except that the origin of 4 is shown as on the left side and its insertion as of the right side (on the right valve). Only the most dorsal fibre of 2 is shown.

Fig. 5. Diagram showing insertions and relative superposition of the muscles (based on *Septis arctica*). Each oblong represents the right half of one segment as seen entally, and the appendages (Pen., V. and Aed.) are placed as if projected back on the body wall. A11 is assumed undeveloped; it may perhaps be incorporated in A10 or A12.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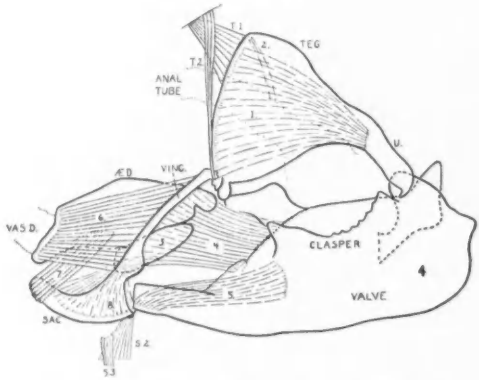
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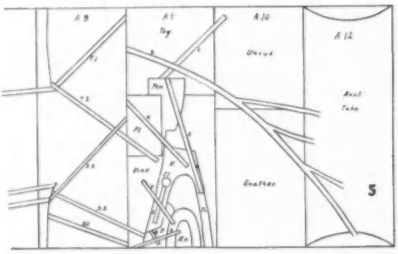
A 9
A 10
A 12
Anal Tube
5

vinculum. In every form I have examined the origin is on the upper part of the vinculum, but in all of these the latter was well developed. 6 is obviously my 5, and its insertion near the base of the valve shows that Hrp. is not the stylus as interpreted by Snodgrass, but merely the usual costal chitinized portion of the valve (coxite). Muscle 7 can only be my 3, running from tegumen to articulation of valve, but its insertion *below* the costa (Hrp.) shows that that structure has rotated 180°. Muscles 8 and 9 presumably represent my 1, running from tegumen to uncus, and the division into two bundles is reflected in a similar subdivision of the sclerite—presumably the 9th tergite. This leaves muscles 2, 4, and 8 unaccounted for. I failed to find the same three muscles in Telea, and suspect that 8 has been lost on account of the lack of function of the juxta. Muscle 4 may not be distinct from 3, in the absence of either penicillus or functional pleurite.

Telea polyphemus (fig. 3).—This species is also considerably reduced but in quite a different way from Bombyx. In this species there is no distinct gnathos, the uncus is ankylosed to the tegumen, which ventrally is completely continuous with the vinculum, and the latter with both juxta and valve; but the costa of the valve has gained its independence in a unique way, and moves vertically in the slit between the tegumen and the rest of the valve.

The muscles are as follows: T. 1. runs from a subdorsal flange on the upper part of the tegumen to the 8th tergite, and is formed of three strong fibres; T. 2. is represented by several irregular fibres attached to the outer side of the tegumen; S. 1. is normal and more massive than S. 2; the insertion of S. 3. was found on the side of the fused vinculum-valve at its proper position.

Of the intrinsic muscles 1 runs as a chord across from the whole inner face of the tegumen subdorsally to a flange on the side of the uncus. There is no suture between tegumen and uncus, but they are flexible dorsally just in front of the flange and the muscle doubtless functions as a depressor of the uncus, as in the Geometridae. Muscle 2 was not definitely recognized. There is a single large muscle representing 4 or perhaps 3 and 4, with its origin on the tegumen near its flange, above the origin of 1, and its insertion on the tendon of the costa, which plunges deep in but articulates with a heavily chitinized transtilla in the typical way. It obviously serves as a depressor of the free costa. Muscle 5 is perfectly normal in character, and its origin and insertion serve to identify the sacculus and clasper in the otherwise amorphous vinculum-valve. The former lies well ventrad in the expected position and can be made out as a slight thinning and bulge of the combined sclerite; the latter is the upper and more massive of the two lobes of the valve. Muscles 6 and 7 are normal, but 7 is rather weak and attached rather low on the side of the aedoeagus, so that it hardly crosses 6. The juxta, while quite recognizable, is immovable, and I can find no trace of muscles 8.

Malacosoma disstria.—This representative of the Lasiocampidae is specialized in quite another way. The 7th sternite is chitinized and toothed at the posterior margin, the 8th sternite heavily chitinized but withdrawn in a deep pocket, while the tergite takes the form of two

large toothed subdorsal lobes, and replaces the tegumen and valves in function. The vinculum is massive but withdrawn into the body closely parallel to the 8th sternite and just above it, while the tegumen and valves are vestigial. The most striking feature of the muscles is the reduction of all dorsal muscles except T. 1., which runs normally, and the massive muscles of the aedoeagus (6 and 7) which meet at a vertical line on the aedoeagus instead of crossing. S. 2. is represented by innumerable short fibres which run directly across from the 8th sternite to the vinculum and do not allow the protraction of the latter. The juxta is completely ankylosed with the aedoeagus, so that the action of muscles 6 and 7 rotates the combination on the junction of juxta with vinculum like a hinge. Muscle 3 is a small fibre running directly from the tendon of the valve dorsad, but muscles 5 and 8 were not found.

Argynnis aphrodite.—The butterflies are universally believed to come off from the Microlepidoptera along a line entirely distinct from any of the higher moths. It may be expected, then, that features shared by the Noctuidae and Argynnis are common to all the Frenatae, except possibly a few of the most primitive Tineoids. In Argynnis the extrinsic muscles work on the same plan as in the moths, except that nothing was found to correspond to the special fibre from 8th sternite to saccus, S. 1. The muscle S. 3. appears to be normal but was not fully traced. The intrinsic muscles (fig. 4) were also normal with the following exceptions. The retractor of the anal tube is represented by a few stray fibres, one of them attached almost to the mid-dorsal line of the tegumen; 1 bends the combined tegumen and uncus as in Telea; the valve has no ental extension, and the muscle from ring to valve (4, perhaps also including 3) runs by exception from the upper part of the vinculum to a serrate internal ridge on the valve, crowding muscle 5 ventrad. The muscle of the juxta, 8, runs almost entirely to the saccus, with only a fibre or two to the extreme base of the valve. It will need study of the most primitive Lepidoptera, perhaps the Cossidae, to determine whether the different positions of muscles 4 and 8 are primitive, or perhaps the result of degeneration of the basal part of the valve.

Microlepidoptera.—In Snodgrass's figure of *Carpocapsa pomonella* muscle 8 is fully developed, almost as in the Noctuidae, but attaches to the juxta a little more dorsally. (l. c., figs. 308 H, I.)

Morphology.—There are two questions of morphological importance on which the muscles may give evidence: the segmental assignments of the parts, and the nature of the appendages. On the first, there are obviously three segments well sketched out (see diagram) to represent segments 9–12 of the fundamental insect plan. We may assume then that either the 11th or the 12th segment is not developed, or that the complexities of the supposed 9th segment come from the fusion of two. If we assume that the ninth segment is single, the tegumen obviously is the tergite and the vinculum the sternite. The small separate lateral sclerite which we have marked Pl. is in the proper position to be a true pleurite, lying as it does between the tergum and sternum, and bearing the upper articulation of the valve. But the fact that when not developed its most distinctive muscles (S. 3 and 4) may attach either to the sternum (S. 3.) or tergum (4 in Geometridae)

makes a little uncertainty. It is also against it that it is found so erratically; but in a Gelechiid in which the ring is extended vertically (Jour. N. Y. Ent. Soc. 46: in press) the sclerite is distinct and bears the entire valve, so it may be more common in primitive types than realized. Its position, relation to the valve, and the way it tends to be bracketed by fine internal chitinizations all favor its interpretation as subcoxa, but there is no final proof.

As to the valve; the muscles plainly indicate that Snodgrass's suggestion in 1931 (Morphology of the Insect Abdomen, Part I, General Structure of the Abdomen and its Appendages, p. 91, with fig. 31B on p. 74) fits the facts better than his later analysis of the Lepidoptera (Principles of Insect Morphology, p. 603). There is no connection whatever between the aedoeagus and the juxta, while the latter is always connected either by muscles or complete fusion with the valve. The clasper when present also always has a muscle, arising at the base of the valve. If we compare the diagrammatic figure 31B of Snodgrass we find that this is the proper relation if the valve is the coxite (LB), the clasper the stylus (Sty) and the juxta the fused gonapophyses of the two sides (Gon),—otherwise the endites. In this case the so-called aedoeagus of the Lepidoptera is the true penis, having no contribution from the appendage, but only muscles of the visceral type, running from the sternite itself right in to the vas deferens or its homologue. The transtilla, articulating as it regularly does with the posterior angle (tendon) of the valve on each side, is no doubt the sternellum. There seems to be no reason to doubt that the uncus (its swollen base rather than the free tip) and gnathos represent the tenth segment. In this case muscle 1 is the dorsal longitudinal, while muscle 2 when present is no doubt visceral. The muscles give no evidence beyond this, but something can certainly be done with the larva and pupa, especially in those Geometridae where the 10th segment is separated by a deep suture from the ninth, as in Cingilia or Sabulodes. The possibility should also be kept open that the anal prolegs of the larva, and therefore the socii of the imago may perhaps belong to the 11th rather than the 10th segment. The large number of setae in front of the proleg, and the extreme anterior position of the "trapezoidal" setae suggest a whole vestigial segment in front of the proleg.

INSECTOS DO BRASIL, 1o Tomo by A. da Costa Lima. This is No. 2, Seire Didatica, Escola Nacional de Agronomia, Avenida Pasteur No. 404, Praia Vermelha, Rio de Janeiro. Pp. 470, 218 text figures. In Portuguese. No price given.

We are constantly surprised at the productivity of Professor Costa Lima. Only recently he gave his country a list of the economic insects of Brazil. The present volume is a work, the first of its kind, which will cover the insects of Brazil as a textbook of taxonomy with emphasis on the groups of economic importance. Volume I covers the Aptera and Exopterygota up to the hemipteroid insects.

Illustrations have been drawn on freely from standard publications. Much general biology from applied entomology has been included. The keys run to families after which the treatment becomes irregular and appears to emphasize economic species. For a first text on the insects of Brazil it is well done.—C. H. K.

ENVIRONMENTAL CONTROL OF SEX IN HYMENOPTEROUS INSECTS[1]

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"The reproduction of insects forms one of the most remarkable chapters in their natural history. The structural adaptations for copulation, the control of the sperm in the body of the female, the micropylar arrangements in the egg which allow fertilization through the fully formed shell, are remarkable enough."—V. B. Wigglesworth, Insect Physiology.

Sex control in the Hymenoptera under normal conditions results in a preponderance of females. Extreme variability in the proportion of sexes, however, is often evident. This condition apparently results from the fact that in the majority of species the males, as a rule, are derived from unfertilized eggs and the females from fertilized eggs. Since the eggs contact the sperms only when moving through the vagina, it is apparent that in arrhenotokous Hymenoptera sex is changed during the process of oviposition. This change in sex which results from fertilization has been shown to occur in the Rotifera (Wilson, 1925) and probably occurs in the Thysanoptera, Hemiptera, and Arachnida. The environmental or external control of sex, reported in the Hymenoptera, is contingent on this phenomenon.

The change in sex can occur only in mated females. Mating takes place, however, in many hymenopterous species during the preoviposition period, immediately following the emergence of the adult.[3] As pointed out by Howard (1891) " . . . The males issue before the females and await the appearance of their mates. . . . "

In such species of Hymenoptera the proportion of early maturing males may be greatly accentuated because mated females deposit more unfertilized than fertilized eggs on small (unpreferred) hosts. According to Taylor (1937) it is reasonable

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[3]Certain species of *Coccophagus* usually mate *after* oviposition begins, since all of the males are the progeny of the unmated females. (Flanders, 1937.)

to assume that in all circumstances the female when ovipositing controls fertilization in response to stimuli from the host. This ability of the mated female to change the sex ratio of her progeny was demonstrated experimentally by Brunson (1937).

In the parasitic Hymenoptera the proportion of males appears to vary inversely with the average size of the host. Chewyreuv (1913), Holdaway and Smith (1932), Seyrig (1935), Taylor (1937), and Ullyett (1936) have observed that in certain parasitic species, individuals resulting from small hosts are usually males and those from large hosts usually females.

The sex-ratio of parasitic Hymenoptera may be influenced by the condition either of the host or of the parasite. It is known that the individuals of a parasitic species vary greatly in their responses to the same host (Jackson, 1937). On the other hand, the individuals of a normal-host population may exhibit a comparatively wide variation in the character of their attributes (habit, odor, shape, size, texture, movement, etc.) as observed by Ullyett (1936). These variations undoubtedly bring about a preferential response on the part of the adult parasite (Salt, 1938). This response may be manifested either by the number of eggs deposited per individual host by a gregarious parasite or by the sex of the eggs deposited by either a solitary or a gregarious species.

The effect of the host on the sex of the parasite[4] is one of the most important factors in the reproduction of parasitic Hymenoptera. Howard (1924) suggests that this factor may account for failures in the establishment of imported species.

THE ROLE OF THE SPERMATHECA[5]

According to Adam (1912), in the Hymenoptera the arbitrary alternation between fertilized and nonfertilized eggs presupposes a mechanism which would function according to the sex of the egg to be laid. Such a regulation of sex production is exemplified in the queen bee, but it has never been adequately explained. One simply states that the queen bee apparently "knows" what kind of an egg she is going to lay and puts each

[4]Some investigators have assumed that the limited quantity or unusual quality of the food of the larvae causes a change in sex. Proof of such a change appears lacking.

[5]Spermatheca: A sac connected with the female reproductive organs of most insects and many other invertebrates, which receives and retains the spermatozoa, often for a long period until the time for fertilizing the eggs.—*From Webster's New International Dictionary.*

in the proper type of cell. So far as we know at present, the control of fertilization in the honeybee depends upon the "will" of the queen, as asserted in 1845 by Dzierzon (Phillips, 1903).

Fabre (1884) investigated this phenomenon but could not arrive at a satisfactory explanation. The spermathecae in the specimens he examined did not appear to be capable of a "fécundation facultative" function. In any insect, however, the spermatheca must serve as a sex-changing mechanism if it contains only female-producing sperms.

Many hypotheses have been advanced to explain the apparent ability of the fecundated female to control the action of the spermatheca (Phillips, 1903). It is evident, as suggested by Schrader (1920) in regard to the arrhenotokous aleyrodid (*Trialeurodes vaporariorum*) that the female fertilizes its eggs in response to a stimulus.

Within the female the effect on the spermatheca of the passage of any egg may be considered constant. In arrhenotokous species, therefore, in which there is discontinuity in the fertilization of the eggs, the production of females must be externally induced. The stimulation of the spermatheca probably results from the contact of the antennae, legs, or ovipositor with the medium on which the eggs are to be deposited. Variations in the condition of this medium may vary the amount of stimulation and it is probable that the spermatheca responds only to stimuli of certain intensities, reacting to its fullest extent or not at all. Such reflex appears to be responsible for the proportion of sexes in many Hymenoptera.

In certain arrhenotokous species, however, the spermatheca, if functional, may be stimulated only by the passage of an egg. According to Clausen (1923), the female of *Schizaspidia tenuicornis* deposits its full quota of eggs soon after mating, at the rate of about one per second during one insertion of its ovipositor. In such species the deposition of unfertilized eggs would occur, for the most part, when the spermatheca is empty of sperms.

It is noteworthy that even in species in which unfertilized eggs develop into females[6] the spermatheca appears capable of functioning. The spermatheca of a thelytokous encyrtid

[6]Cytological studies of *Habrobracon* by Speicher and Speicher (1938) show that in thelyotokous reproduction the unfertilized eggs are tetraploid before reduction and, therefore, diploid after reduction. The amount of tetraploid ovarian tissue apparently determines the proportion of parthenogenetically produced females in a species. If such is the case, thelyotoky may be environmentally induced.

(*Encyrtus* sp.) which had mated with one of the rare males was found to contain sperm.

In attempting to reach an explanation for the apparent ability of the Hymenoptera to control the sex of their progeny, the investigator is limited to comparative morphological studies of the spermatheca and correlation of its structure with the sex-producing habits of the species. My observations for the most part have been limited to fifteen species of aculeate and parasitic Hymenoptera.

STRUCTURE AND OPERATION OF THE SPERMATHECA

A detailed knowledge of the structure of the spermatheca is prerequisite to the most logical theory of the way it functions in controlling the fertilization of the egg. This organ, which is attached to the dorsal wall of the vagina, consists of three distinct parts (figures 1, 2, 3, 4, 5, 6, 7); a more or less rigid sperm receptacle or capsule, a spermathecal gland and its canal, and a sperm duct connecting the sperm capsule and the vagina. In many species a sperm valve occurs in the sperm duct adjacent to the capsule (figures 4, 6). This valve is essentially an infold or ridge in the wall of the sperm duct. The sperm duct is characteristically curved or elbowed at the point where the valve is located.

A comparative study of the spermatheca of various Hymenoptera reveals two distinct types, depending on the structure of the mechanism regulating the *number* of sperms discharged at one time. In type I, represented by the honeybee and *Tiphia*, the number of sperms discharged simultaneously appears to be determined by the amount of glandular fluids passing through the valve into the comparatively wide sperm duct (figure 6). This is indicated by the fact that the spermathecal gland discharges directly into the sperm capsule or into a duct between the capsule and the valve. In type II, represented by the ichneumonids, braconids, and chalcidoids, the gland empties into the lumen of the sperm duct, which is so narrow adjacent to the capsule that apparently only a single sperm can move in or out at one time (figures 1, 2, 3, 4, 5).

In most species the secretions elaborated in the gland pass from numerous minute channels into a larger canal. In the braconids, however, the minute channels open into a large central reservoir; an enlargement of the gland canal. In certain braconids (*Chelonus blackburni* Cam.) this reservoir is about equal in size to the sperm capsule.

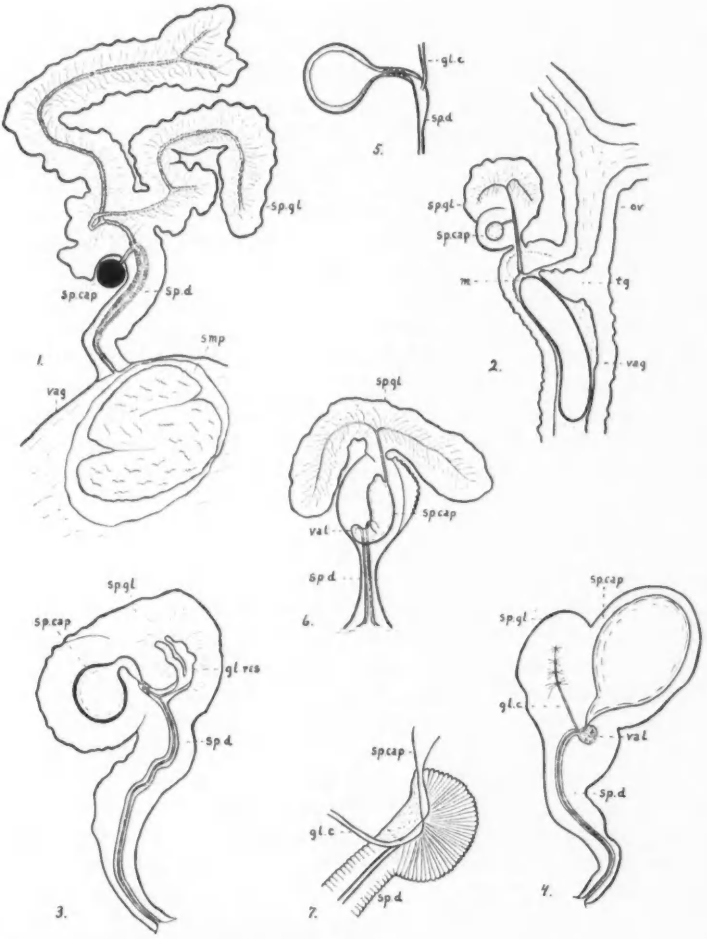

Fig. 1. Spermatheca of *Calliephialtes*.
Fig. 2. Oviduct, spermatheca and vagina of *Nemeritis*. Egg in position to receive a sperm. (Camera-lucida drawing.)
Fig. 3. Spermatheca of *Habrobracon*.
Fig. 4. Spermatheca of *Scutellista*.
Fig. 5. Sperm capsule of *Nemeritis*.
Fig. 6. Spermatheca of *Tiphia*.
Fig. 7. Sperm valve of *Scutellista*.

Symbols: gl. c., gland canal; sp. d., sperm duct; sp. gl., spermathecal gland; sp. cap., sperm capsule; m., micropyle of egg; ov., oviduct; tg., tongue; vag., vagina; val., valve; gl. res., gland reservoir; smp. spermatophore.

In the ichneumonids and braconids the lumen of the sperm duct between the sperm capsule and the gland canal is spirally convoluted corresponding in its structure to the undulations of active sperms. There is no visible structure that may represent a valve such as occurs in the chalcidoids or in the aculeates.

In some species (*Calliephialtes*, *Chelonus*) the sperm capsule is brittle and opaque; in others (*Habrobracon*, *Coccophagus*) it is pliable and transparent. In spermathecae dissected into physiological salt solution, the sperms may be clearly visible revolving *en masse* within the capsule. The extremities of a few of the sperms are always caught in the neck of the capsule and extend as far as the sperm duct, where they remain stationary although rapidly undulating. The waves which proceed backward from the extremities of these sperms create the illusion that each sperm is moving swiftly backward. The polarity of the thread-like sperms can be ascertained only by the direction of wave movement. This indicates that in the aculeates and chalcidoids the sperms, when caught in the neck of the capsule, abut the valve with their anterior extremities.

When the spermathecae of chalcidoids are dissected into physiological salt solution, they occasionally bend spasmodically. As previously noted, the sperm valve is located at the elbowed portion of the sperm duct. The bending movement probably results from the contraction of muscles in the thick wall surrounding the duct. The lumen of the duct may be opened momentarily by such a movement. As suggested by Breslau (1905–1906) in the case of the honeybee an increase in the curvature of the duct at the elbow would open the lumen by raising the infolded wall. Presumably the reflex opening the valve operates when there is present in the vagina either the sperm-containing male secretions or an egg in the process of being deposited.

In species with wide sperm ducts, the sperms after escaping from their coiled state in the capsule may be aided in their movement along the sperm duct by the glandular fluids. This is a function ascribed to these fluids by earlier investigators.

In the bees[7] and wasps, the sperm duct and particularly the spermathecal gland are much larger (relative to a sperm) than in the braconids and chalcidoids.

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[7]The queen bees used in this study were contributed by J. E. Eckert, of the University of California staff at Davis.

In the ichneumonids also the lumen of the sperm duct (except the portion between the gland canal and the capsule) is comparatively wide. In the braconids and chalcidoids the lumen of the sperm duct is uniformly narrow throughout its length. In spermathecae of type II, the spermathecal gland is largest in the ichneumonids (figure 1) and smallest in the chalcidoids (figure 4).

As stated above, the sperm duct in the ichneumonids and braconids is in part spirally convoluted, corresponding to the undulations of the sperms (figures 3 and 5). Apparently these convolutions provide for the locomotion of a sperm in the duct. It is obvious that an extremely narrow duct longer than the sperms and lacking such convolutions would inhibit their locomotion. It is significant that the lack of convolutions in the chalcidoid sperm duct is correlated with the occurrence of sperms that are longer than the duct. In the chalcidoids the importance of the glandular secretions may lie more in the activation of the sperms than as a medium of movement through the sperm duct.

The differences in the size of the gland appear to be correlated with the need of fluids as a medium for the movement rather than for the activation of the sperms.

Activation and Movement of Sperms.—Many workers have assumed that the spermatheca inducts and discharges sperms through a common channel almost entirely by muscular activity. The structure of the spermatheca, however, indicates that this reversible action is more glandular than muscular in origin.

The studies of other investigators (Lillie, 1919) on the thigmotropic and chemotropic responses of sperms suggest an adequate explanation to account for the migration of sperms into and out of the sperm capsule. These investigators have shown that sperms are activated by weak alkalies and inactivated by acids. The degree of activity was found to be a function of the H-ion concentration of the medium, other things being equal. The sperms, therefore, react positivley to CO_2 gradient, tending to accumulate by "trap action" in a region of increased CO_2 tension. Since all of the sperms deposited in the vagina by the male migrate into the sperm capsule, it is reasonably certain that a CO_2 gradient extends from the vagina to the sperm capsule. After copulation the medium in the vagina is alkaline, for a short time at least, as indicated by the activity of the sperms.

In spermathecae with extremely narrow sperm ducts, as in the braconids, the locomotion of the sperms into the capsule may be facilitated by undulations of the duct provided that the waves of the duct and of the sperms are about equal. This possibility is indicated by the structure of the duct (figure 3).

According to Lillie, when sperms form dense aggregations those in the interior become quiescent, apparently inactivated by their own CO_2. The sperms thereby conserve their enegry for years. When the spermathecae of *Tiphia*[8] are dissected into physiological salt solution the sperms are all inactive when first observed. As the solution penetrates the sperm capsule, the sperms begin to move and soon are in rapid action.

In the female, therefore, as in the male, it appears that the sperms are activated by alkaline secretions. The morphology of the spermatheca and the behavior of the sperms within it preclude the possibility that the secretion of the spermathecal gland is other than alkaline. Since this gland empties either into the capsule or into the sperm duct at a point adjacent to it, a reversal of the CO_2 gradient between the sperm capsule and the vagina is possible. Hence it appears that the discharge of sperms, occurring in response to the passage of an egg into the vagina is dependent in part on the activation of the sperms and the reversal of the CO_2 gradient.

A correlated phenomenon reported by Lillie is the change in locomotion of the sperms from a progressive to a circular form. Because of this reaction, sperms tend to collect in a region providing a stimulus to rotation. This change may be caused either by the type of surface with which the sperms are in contact or by the degree of CO_2 tension of the medium. When activated by physiological salt solution, the sperms in the sperm capsule rotate in the counterclockwise direction characteristic of flagellate sperms in general. As they rotate, some are caught in the neck of the capsule leading to the sperm duct, where they must remain until discharged.

Mechanisms Synchronizing Discharge of Sperm and Egg.—The possession of a spermatheca presupposes the need of conserving sperms. The discharge of a sperm, therefore, should coincide with the extrusion of an egg from the oviduct. In the Hymenoptera there appear to be two methods of accomplishing this synchronization.

[8]The specimens of *Tiphia* were supplied by the Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture, through the courtesy of C. P. Clausen.

The movement of sperms into the vagina in the aculeates and in the chalcidoids may be synchronized with the passage of an egg through activation of the valve muscles. In the honeybee and *Tiphia* sperms may be discharged into the sperm duct when the valve opens, provided the glandular fluids are under pressure in the capsule. The opening of the valve probably is independent of this pressure since it also must open for sperms to enter the capsule. In the chalcidoids the sperms, because of their extraordinary length, may move outward unassisted by the glandular excretions. In species possessing spermathecae lacking a sperm valve (figures 1, 2, 3), the discharge of a sperm apparently depends on muscular contraction of either the gland (in the braconids) or of the sperm duct (in the ichneumonids); the reaction in each case being stimulated by the position of an egg in the vagina. In these groups the structural convolutions of the lumen of the duct between the capsule and the gland canal enable the sperms to move from the capsule to a point in the sperm duct beyond the gland orifice, thereby reaching a position for discharge with the glandular fluids under pressure.

The structure of the spermatheca in *Nemeritis canescens* (Grav.), a thelyotokous species (figure 2), may be typical of certain ichneumonids and braconids. The micropyle of the egg as it passes through the vagina apparently is placed flush with the orifice of the sperm duct by a muscular tongue projecting from the floor of the vagina. The egg is then in position to receive a sperm. A similar tongue is present in the honeybee (Snodgrass, 1925).

If only the presence of an egg in the vagina caused the discharge of sperms, all of the eggs of a female would be fertilized as long as the capsule contained sperms and the rate of oviposition did not exceed the rate of sperm discharge. That this does not occur indicates that the source of gland stimulation is external. The fertilization of hymenopterous eggs, therefore, is externally induced.

THE INFLUENCE OF THE SPERMATHECA ON THE SEX RATIO

When the capacity of the gland is sufficient to bring about the fertilization of all the eggs, irrespective of the rate at which they are deposited, the sex ratio, if any, must also be externally induced. If the gland lacks the capacity to bring about the fertilization of all eggs, because of a high oviposition rate, the

sex ratio when oviposition occurs rapidly on preferred hosts is in part internally induced. Leiby (1926) suggests that in the oviposition of *Platygaster hiemalis* eggs may not receive a sperm if they pass the spermathecal duct rapidly. The capacity of the gland and the number of eggs deposited per host, therefore, may determine the type of sex ratio.

A comparison of the spermathecae from the various species shows that in the aculeates and ichneumonids a much greater amount of glandular fluid probably is required to bring about the fertilization of an egg than in the braconids and chalcidoids. This is also indicated functionally by the fact that the former apparently deposit only one egg at a time whereas the latter may deposit more than one in rapid succession.

It seems evident that the production of males by mated females may depend either on the inadequate stimulation of the gland or on the depletion of its secretions.

Externally Induced Sex Ratios.—Ullyett (1936) has shown that the hymenopteron *Microplectron* is able to ascertain the shape of an object by antennal exploration and that it exhibits a definite preference for the larger objects. It is probable that the ovipositing honeybee can likewise distinguish between different shapes and sizes, since the spermatheca is activated only by cells of a certain shape or size. The capacity of the spermathecal gland in the honeybee is sufficient to bring about the fertilization of every egg, irrespective of the oviposition rate, so that the sex ratio is determined by the size of the available cells. Even when the cell is unfinished and short, as are queen cells and occasionally worker cells, the fertilization reflex occurs. However, it does not occur when the egg is deposited in large (drone) cells. It is significant that oviposition occurs in drone cells during maximum honey-flow, when the greatest number of the cells are being used for the storage of honey.

Brunson (1934) and Taylor (1937) have shown that in *Tiphia* and *Pleurotropis* the predominant stage or condition of the host determines the sex ratio. I have found this to be true in a species of *Metaphycus* introduced from Africa into California during 1937. Fecundated females deposit only unfertilized eggs in specimens of *Saissetia oleae* (Bern.) 1 mm. in length. Fertilized eggs are deposited in specimens ranging in size from 1⅓ mm. to 2½ mm.; the proportion of male progeny decreasing as the size of the host increases. In each of the species mentioned above, the stimuli to which the female reacts in appar-

ently distributing her eggs according to the sex are definitely associated with the size of the repository or host. Brunson (1937) states that *Tiphia* females showed a decided preference for large (third instar) host larvae but that they oviposited readily on small hosts if the preferred hosts were absent. However, a greater proportion of female progeny was obtained from the preferred hosts. Possibly if oviposition occurred on unusual hosts, all the progeny would be males. Taylor (1937) found this to be true of the parasite *Pleurotropis parvulus*. He stated that the abnormal nature of the host was in some way connected with the production of males.

The effect of the host on the sex ratio of its parasite is most noticeable with species that deposit their eggs singly. In gregarious species that deposit more than one egg per host, the sexes usually are intermixed except when deposited on an unusual or unpreferred host, in which case all the progeny may be males. According to Ullyett (1936), *Microplectron fuscipennis*, a gregarious species, shows a definite preference for large hosts, although a small host is capable of supplying the food material necessary to bring to maturity the total progeny of a female. The adult parasites arising from small hosts are usually males.

It is evident that the production of males in many species is an effect of inadequate external stimulation of the spermatheca. In a few species, however, the production of males may be an effect of a limited sperm supply; the spermatheca being stimulated by the host uniformly or not at all. In *Melittobia acasta* the sex ratio appears to be determined by the fact that the female exhausts the supply of sperms before she ceases to oviposit (Thompson and Parker, 1928). Mating may occur a number of times, depending on the depletion of sperms in the spermatheca.

Prof. Harry S. Smith, who first studied the biology of this species in 1909, informed me that the total number of eggs deposited by unmated females is very small compared to the number deposited by mated females, but that the number of unfertilized eggs deposited by the latter is approximately equal to the total number deposited by the former. Apparently oviposition to a great extent is dependent on the presence of sperms in the spermatheca.

Internally Influenced Sex Ratios.—In the absence of superparasitism, mated females of gregarious species usually produce progeny of the same ratio under laboratory conditions as in the

field. There may be a tendency for gregarious species to deposit all of the mature eggs in the ovary at once but, as a rule, the number of eggs deposited on a host is determined by the size of the host (Thompson and Parker, 1927). Taylor found that in *Pleurotropis* the maximum number of mature eggs available for discharge at any one time is 36, and all of these may be laid on one large host if the hosts are rare.

The sequence of fertilized and unfertilized eggs is probably determined by the rate of oviposition, an increase in rate increasing the proportion of eggs escaping fertilization. At a high rate the capacity of the gland may be inadequate to supply fluids sufficient for sperm discharge or the muscles of the synchronizing mechanism may be tetanized. A sequence of males resulting from the lack of synchronization is certain to be interrupted through the depletion of the ovaries of mature eggs. The sex of the first offspring after a resting interval should usually, if not always, be female, assuming that the sperm capsule contained sperms and that the eggs are deposited in a preferred host.

When a fecundated female of *Copidosoma truncatellum* deposits two eggs at one insertion of the ovipositor, the second egg is without a sperm in at least 80 per cent of the instances. Eggs deposited singly without a sperm are rare (Leiby, 1926).

Trichogramma sp. deposits three eggs during a single insertion of the ovipositor; the first is fertilized, the second usually fertilized, and the third is unfertilized (Flanders, 1935; Jones, 1936). The normal sex ratio is two females to one male. Recently Powell (1938) has observed a similar phenomenon in the case of an ectoparasitic vespoid wasp, *Cephalonomia tarsalis*, which deposits its eggs in pairs, normally a pair to each host larva. The first egg is fertilized and the second is unfertilized. The second egg is deposited shortly after the first.

Solitary species, on the other hand, when reproducing on preferred hosts under laboratory conditions, often differ greatly in the proportion of sexes from those reproducing under natural conditions in the field. An example of this phenomenon is reported by Bradley and Burgess (1934) in their study of *Cremastus flavoorbitalis*. They found the sex ratio in field-collected material to be 62.1 per cent females and 37.9 per cent males, whereas the progeny of mated females under laboratory conditions consisted of 31.5 per cent females and 68.5 per cent males.

In this case the preponderance of males is obviously not the result of unusual hosts or differential mortality. The causative conditions appear to be either the availability and density of the host or high temperatures. It is significant that both of these factors influence the rate of oviposition. Whiting and Anderson (1932) found that *Habrobracon* produced fewer biparental offspring when the mothers oviposited at 30° C. than when they oviposited at 20° C.

It has been observed with certain Hymenoptera that the proportion of males is much greater at the end of the season than at the beginning (George, 1927). If the stages of the host are constant, the more obvious factors influencing such a condition are host density and temperature.

THE INFLUENCE OF DIFFERENTIAL MORTALITY ON THE SEX RATIO

When gregarious species attack small preferred hosts, the male sex may predominate because of differential mortality resulting from superparasitism. Vandel (1932) states that when many parasites inhabit a host the male sex predominates because of selective elimination of the females rather than through the direct influence of a sex-determining mechanism. Salt (1936) found this to be the case with *Trichogramma*. Taylor observed an excess of males in *Pleurotropis* and, in spite of the fact that his data show that superparasitism occurred, he states that the difference in sex ratio of progeny from large and small hosts "appears attributable to ability on the part of the female to control the fecundation of the eggs."

When a solitary parasite, such as *Brachymeria fonscolombei* deposits more than one egg per host but only one egg at a single insertion of the ovipositor (Roberts, 1938), the larva from the first egg usually survives, so that differential mortality is not common. The fact that females predominate indicates that the first egg in preferred individual hosts is usually, if not always, female; provided that the hosts are not too quickly available for parasitization.

A differential mortality during development may occur, however, in solitary endoparasitic species because of the better adaptation of the female to large hosts and of the male to small hosts. The mortality of the male larva in large hosts is higher because they are less able to consume the host's tissues before decomposition sets in. The mortality of the female larva in

small hosts is higher because of insufficient food. This type of differential mortality resulting from developmental sex differences was observed by Jackson (1937) in *Pimpla examinator*.

An extreme case of this type of differential mortality occurs when the mated females of certain aphelinids, particularly of the genus *Coccophagus*, oviposit in a previously unparasitized coccid. Such hosts are suitable only for the development of the female sex (Flanders, 1937). Male eggs may hatch but they rarely, if ever, develop beyond the first instar. The male progeny of unmated females, however, develop because they are placed in a suitable environment; that is, a hymenopterous larva or pupa within a coccid.

SUMMARY

When the spermatheca in hymenopterous insects is stored only with female-producing sperms, as in the case with arrhenotokous species, it becomes a sex-changing mechanism. The sex of the deposited egg is determined during oviposition. Since a spermatheca containing only female-producing sperms, and stimulated regularly by the passage of the eggs through the oviduct and vagina, would bring about the deposition of female eggs only, it follows that the spermatheca in arrhenotokous species is subject to external regulation. Mated females produce offspring of both sexes, but the sex ratio is variable because the action of the spermatheca is determined by inconstant environmental factors. In general, the sex ratio of the eggs deposited by arrhenotokous species appears to be largely externally induced.

A comparative study of hymenopterous spermathecae indicates that the reflex controlling the discharge of sperms involves the spermathecal gland. The glandular fluids apparently are alkaline and serve to activate the sperms.

The movement of sperms in and out of the spermatheca probably takes place as follows: When the sperms are deposited in the vagina a CO_2 gradient is established, which gives direction to the locomotion of the sperms so that they accumulate by "trap action" in the capsule of the spermatheca, where they are inactivated by their own CO_2. The locomotion of sperms through an extremely narrow duct may be effected by undulations of the duct. When a mated female oviposits in a preferred host, the sperms are activated by the secretions of the spermathecal gland and rotate within the capsule. During the

process of rotation one or more are caught in the orifice of the sperm duct. At the same time the glandular secretions cause a temporary reversal of the CO_2 gradient. Under these conditions an egg entering the vagina brings about the discharge of a few sperms or perhaps only one sperm. The synchronization of sperm and egg discharge is accomplished in the aculeates and chalcidoids by the opening of the sperm valve, and in the ichneumonids and braconids by the contraction of the enlarged portion of either the sperm duct or the gland canal.

The great variation in the size of the spermathecal gland (relative to the length of the sperms) apparently is correlated with the width of the sperm ducts and the necessity of utilizing the glandular fluids as a medium of sperm movement.

If the discharge of sperms from the spermatheca is in any degree inhibited by a high oviposition rate, an internally induced sex ratio results. Such a sex ratio may occur in gregarious species which deposit several eggs per host, or in solitary species ovipositing under conditions of high host density.

It is apparent that the spermatheca is more frequently inactive when oviposition occurs on an unpreferred host or at a high rate of oviposition.

The production of males is assured in solitary species by oviposition on the unpreferred individuals of the normal host and in gregarious species by the rapid deposition of eggs on an individual host.

The sex ratio of deposited eggs may be obscured by differential mortality resulting from superparasitism or from developmental sex differences.

In the propagation of arrhenotokous parasites a maximum efficiency necessitates the production of both sexes, the use of preferred hosts at low densities, and the avoidance of superparasitism.

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FOUR NEW ARIZONA COLEOPTERA

(Cleridae, Corynetidae and Buprestidae)

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Priocera chiricahuae n. sp.

(Pl. I, fig. 3)

Brunneus above and below; abdomen lighter; each elytron with three small yellow spots, one at base, a lateral one in front of middle and another back of middle along suture; legs and body with long hairs.

Head convex, front confluently punctured, vertex transversely rugose; eyes coarsely granulate, hairy, emarginate; last joint of labial palpae triangular; maxillary palpi with last joint elongate; antennae reaching to humeral angles of elytra when laid along sides of pronotum, eleven jointed, scape stout, second joint short, third joint twice as long as second, joints four to ten inclusive serrate, last joint elongate.

Pronotum longer than wide, wide in front, constricted at base; anterior margin broadly rounded; basal margin also rounded; sides sinuate in front, acutely rounded posteriorly; disk convex, a raised area in middle in front of scutellum, two others each side of middle line, a lateral depression each side in front; surface finely punctured, rugose on sides. Scutellum small, oval.

Elytra with umbone prominent, wider than prothorax; sides nearly parallel, broadly rounded posteriorly; disk convex; surface coarsely punctured, punctures becoming obsolete posteriorly.

Abdomen densely punctured, pubescence short, last ventral segment truncate. Tibiae with an apical excavation. Fourth tarsal segment approximately equal in size to the third.

Length 11.5 mm.; width 3.3 mm.

Described from one specimen collected under the bark of a dead pine tree in the Chiricahua Mountains, Arizona, on July 22, 1937, by D. J. and J. N. Knull. *Holotype* in the writer's collection.

The color and markings of the dorsal surface will distinguish this species from the other three species occurring north of Mexico.

Ichnea elongata n. sp.

(Pl. I, fig. 4)

Narrow, elongate, piceous throughout, more shining beneath, pubescence of same color.

Head convex with depression between eyes on front; surface finely densely punctured; eyes large, finely granulate, deeply emarginate

internally, separated by about width of last antennal joint at narrowest point; antennae ten jointed, reaching beyond middle of pronotum when laid along side margins, scape stout, second joint small, slightly wider than long, remaining joints broadly flattened, third to seventh inclusive very short, much wider than long, eighth and ninth elongate, last joint oval, last three joints together longer than rest of antennae.

Pronotum longer than wide, slightly wider in front than at base; sides parallel in front, broadly rounded to base; disk convex, a basal depression on each side; surface finely punctured, punctures much coarser at sides. Scutellum small, oval, granulate.

Elytra at base considerably wider than widest part of pronotum; sides straight, divergent posteriorly, broadly rounded apices; disk convex, a basal depression each side near humerus; surface coarsely closely punctured, irregularly placed punctures larger posteriorly, each elytron with three irregular indistinct costae in addition to the well marked sutural costa.

Abdomen beneath glabrous, punctures very fine and sparse on all but last two segments, last segment densely punctured. Anterior tibiae serrate exteriorly. First joint of posterior tarsus as long as next three united, fourth joint indistinct, imbedded between the lobes of the third.

Length 8.4 mm.; width 2.4 mm.

Described from one specimen collected at Williams, Arizona, August 9, 1938, by D. J. and J. N. Knull *Holotype* in writer's collection.

I have placed this species in genus *Ichnea* due to the ten-jointed antennae. In addition it can be separated from its relative, *Neichnea laticornis* (Say) by its larger size, color, much longer pronotum and narrower space between eyes.

Acmaeodera wickenburgana n. sp.

(Pl. I, fig. 1)

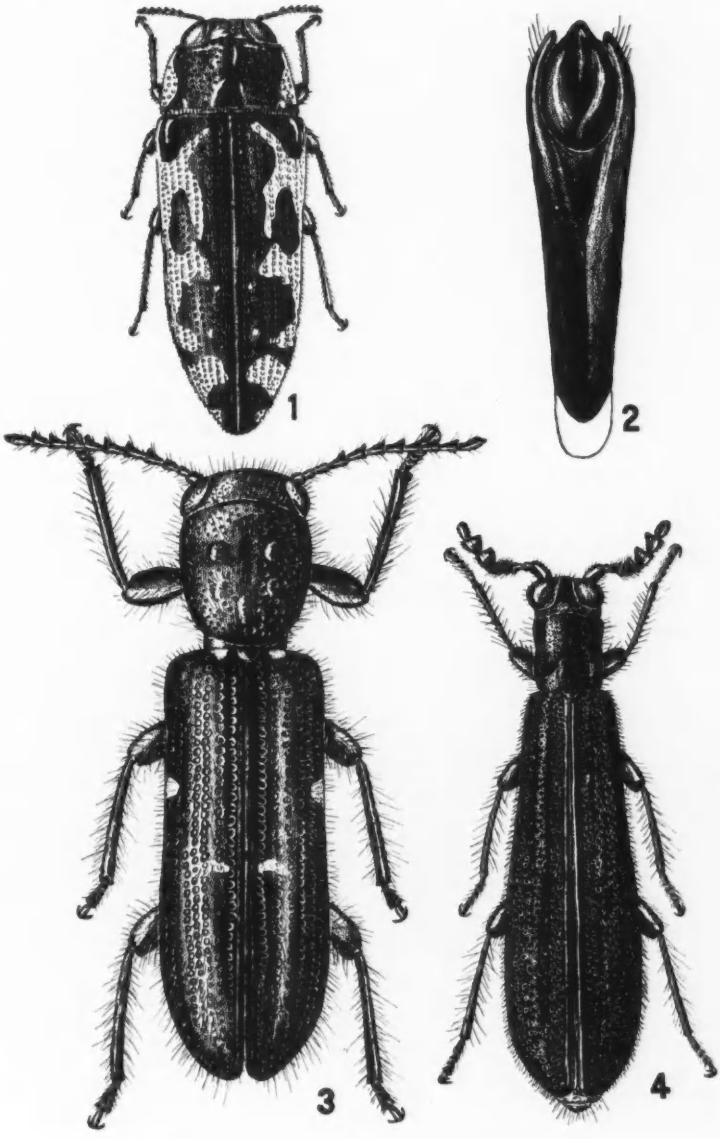
Bronzed above and below; lateral yellow marking of pronotum extending nearly to base and apex, much wider posteriorly; elytra with irregular yellow markings as indicated in illustration; pubescence short above and below.

Head depressed between eyes; surface densely coarsely punctured; antennae serrate from the fifth joint, outer joints wider than long.

Pronotum about twice as wide as long, widest at base, narrower at apex; side margins converging anteriorly, acutely rounded in front; lateral margin visible in front when viewed from above; basal margin truncate; anterior margin trisinuate; disk convex, three small depres-

EXPLANATION OF PLATE

1. *Acmaeodera wickenburgana* n. sp.
2. Male genitalia of *Agrilus hualpaii* n. sp.
3. *Priocera chiricahuae* n. sp.
4. *Ichnea elongata* n. sp.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sions along base, one at middle and one at each side one-third from margins, a broad lateral depression each side; a slight median depression in front; surface coarsely punctured, punctures coarser and closer along base and at sides.

Elytra wider than pronotum, widest at base; sides constricted at middle, broadly rounded posteriorly; side margins serrate from middle to apices; disk convex, umbone prominent, a broad depression in scutellar area; surface coarsely striately punctured, punctures of interspaces sparse, fine.

Front margin of prosternum sinuate, retracted, sides not reaching front angles. Last ventral truncate at tip, with narrow transverse plate, the free edge evenly rounded.

Length 6.8 mm.; width 2.4 mm.

Female.—Differing from the male by the broadly rounded last abdominal segment, and lack of the transverse submarginal plate.

Holotype male collected at Wickenburg, Arizona, August 20, 1938; *allotype* and *paratype* taken at Tucson, Arizona, August 27, 1938, by D. J. and J. N. Knull. Type material in writer's collection.

This species goes in Fall's[1] sinuate group, and would come near *A. quadriseriata* Fall. It can be distinguished from this species by the form of the thorax and lack of long pubescence.

Agrilus hualpaii n. sp.

(Pl. I, fig. 2)

Male.—Shining cupreous above and below, a pubescent stripe extending along suture of each elytron and continuing along each side of pronotum.

Head with front depressed; surface granulose, punctures more distinct on vertex, pubescence moderate; antennae when laid along side margins not reaching middle of pronotum, serrate from the fifth joint.

Pronotum wider than long, wider at base than in front, widest at middle; sides broadly rounded in front, sinuate at base; when viewed from the side, marginal and submarginal carinae separated for their entire length; anterior margin sinuately rounded; base emarginate at middle of each elytron; disk convex, without median depression, a well marked depression on each side along lateral margin, prehumeral carinae prominent; surface finely obliquely rugose, punctures small. Scutellum granulose, not carinate.

Elytra about as wide as pronotum at base; sides parallel in front, constricted at middle, expanded back of middle, apices rounded, serrulate; disk slightly flattened, sutures strongly elevated posteriorly, moderately deep basal depressions; surface closely imbricate.

Abdomen beneath densely punctate and pubescent, first and half of second segment with a pubescent slight median depression; pygidium longitudinally carinate, carina not projecting. Prosternum densely

[1]H. C. Fall, Jour. N. Y. Ent. Soc., VIII, pp. 1–37, 1899.

punctate, pubescent; prosternal lobe truncate, slightly emarginate; prosternal process expanded back of coxal cavities. Tibiae slender, anterior and middle pairs mucronate on inner margin at apex. Posterior tarsi shorter than tibiae, first joint only slightly longer than second. Tarsal claws similar on all feet, cleft, the inner claw much shorter than the outer one and not turned inward.

Length 7 mm.; width 1.9 mm.

Described from one male specimen collected in the Hualpai Mountains, Arizona, August 6, 1938, by D. J. and J. N. Knull. *Holotype* in writer's collection.

According to Fisher's key[2] this species would run to *A. felix* Horn. It can be separated from Horn's species by the finer sculpture of the pronotum and by the marginal and submarginal carinae being separated for their entire distance.

[2]W. S. Fisher, U. S. Nat. Mus., Bul. 145, pp. 1–349, 1928.

A CONTRIBUTION TO THE BIOLOGY OF NORTH AMERICAN VESPINE WASPS, by CARL D. DUNCAN. Pages 1–272, 255 figs. on 54 pls. 1939. 7 x 10 inches. Published as Stanford University Publications, Univ. Series, Biol. Sci., Vol. VIII, No. 1, by STANFORD UNIVERSITY PRESS, Stanford University, Calif. Price, paper bound, $2.50; cloth bound, $3.25.

This work by Professor Duncan of the San Jose State College is the summary of twenty years of study on vespine wasps. The first eighty pages and thirty plates are on anatomy which, because of the excellent illustrations, constitute probably the most detailed treatise on vespine skeleton and musculature that we have. Twelve pages are given to the structural and habit characteristics of the genera Vespa, Vespula and Dolichovespula. Eighty pages and twenty-four plates are devoted to the biology of the Vespinae under the general heads, "Seasonal History of a Wasp Colony," "Hibernation," "Foods and Feeding Behavior," "Building Activities," "Life History" and "Metamorphosis." This portion of the book makes interesting reading. We recommend it to all entomologists who take classes afield.

As with the biology of all social insects the habits of the Vespinae are interesting to a socius of our own society. From Sunday School on we are taught that a society is based on self-sacrificing behavior. From the daily papers we soon learn that some societies value purges, confiscatory taxes and other forms of force. We find that insect societies are no different. With abundant food and an easy life the society flourishes. When times get hard and starvation faces a colony the self-sacrificing nurses eat the babies. Then, too, the gracious habit of *Vespa crabro* who, when she catches a honey bee, rips open the abdomen and honey crop and laps up the nectar it contains! Nice animals are socii of almost any society!

As vespine wasps extend across North America from coast to coast and are among the first wasps observed by students interested in insects, this volume can well be included in that first list of books on habits and structure of common insects. The common species are readily identified by the figures of the color pattern of the abdomen of the queen and workers.

Professor Isabel McCracken of Stanford University did entomology a favor when she suggested to her student, Carl D. Duncan, that he study vespine wasps for a Doctor's thesis. On the basis of that earlier paper has been built this valuable volume.—C. H. K.

ARCHAEOPODAGRION BICORNE, A VERY PRIMITIVE DRAGONFLY FROM EASTERN ECUADOR

(Odonata: Megapodagrioninae)

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Ohio State University
Columbus, Ohio

Specimens of this very rare species have been sent up from Ecuador at the rate of about one a year for the past four years. Because of the smoothly curved veins they have usually been packed away among the hundreds of unsorted Heteragrions with which they have been shipped by the collector, Mr. Wm. Clarke-Macintyre, Esq. They come from small jungle streams of the low, hot eastern end of Ecuador, "The Oriente." Because of reasons given later the writer considers Archaeopodagrion n. gen. one of the most primitive members of the very primitive Megapodagrioninae. It is a connecting link between two major South American groups of this subfamily. It would not be out of place among fossils of the Miocene or even of the Eocene.

Archaeopodagrion = Ancient Podagrion; *bicorne* = two horned: "The Two-horned Ancient Podagrion," in reference to its great primitiveness and the two horns on the prothorax of the male. Types at present in the writer's collection.

Archaeopodagrion n. gen.

Legs with slender spines twice as long as interspaces; legs of moderate length, apex of femur reaching base of abdominal segment two. Frons rounded (no transverse sharp edge). Second hamules of male second segment of abdomen shelf-like (not hooks). Penis with a single row of spinous hairs on either side of shaft; terminal segment bifurcate almost to base; the two terminal lobes thus formed are long slender straps.

Male apical abdominal appendages forcipate; inferiors well developed.

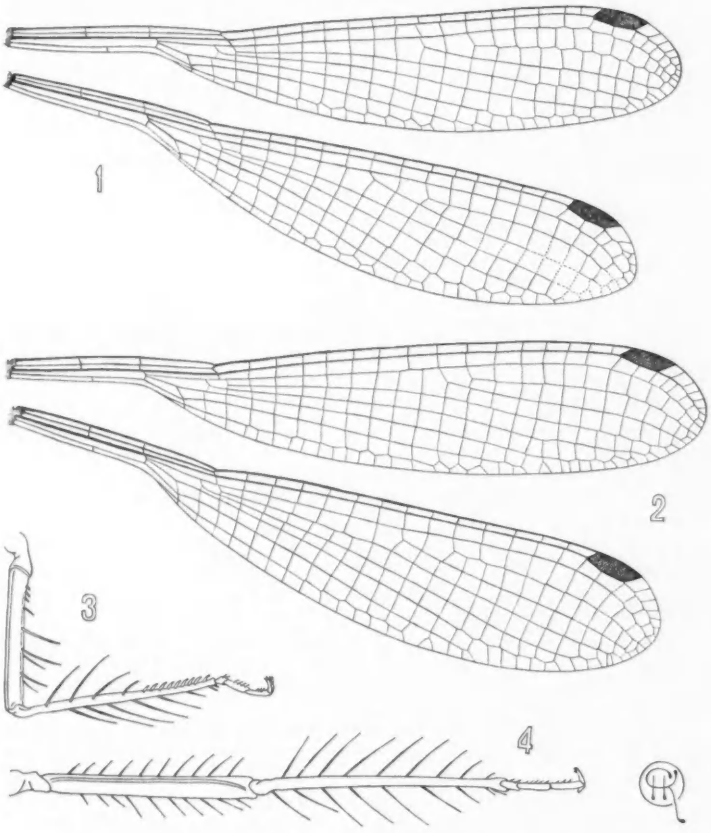
Wings petioled to middle level of quadrangle. Two antenodals. Stigma long, subtending 2 to 3 R_1 cells. No extra sectors besides M_{1a}. Rs and M_3 arise near subnodus (as in Coenagriidae). M_{1a} and M_2 arise within two cells of each other half way between nodus and stigma. Usually long veins smoothly curved (as in Heteragrion). Ac at a level slightly beyond that of first antenodal. Quadrangle long, narrow, widening at outer end to twice the width at base: outer side sloping. (*A wing as in the genus Megapodagrion but with no extra sectors besides* M_{1a}.)

Genotype = *Archaeopodagrion bicorne* n. sp., described next.

Archaeopodagrion bicorne n. sp.

(Figs. 1–21)

Holotype, male, color. Labrum, ante-clypeus and genae white, the lower third of labrum with a faint orange cast: post-clypeus black with a pair of minute white dots: frons, vertex, occiput and under surface of head black. Antennae black with pale membrane at apex of basal segment. Labium pale with black "movable hooks."



Figs. 1–4. *Archaeopodagrion bicorne* n. gen., n. sp.

1. Left fore wing, lower surface, right hind wing, upper surface, of male "Canelos, Oriente, 12–XII–38," Ecuador. (The fore wing is abnormal in the great amount of zig-zag in M_1, which in the other fore wing and in those wings of all other specimens is nearly smooth as in the fore wing, fig. 2. 2. Left fore wing and right hind wing of female, Partidero, Rio Anzu. 3. Fore leg of male, Canelos. 4. Hind leg of male, Canelos, Rio Pastaza watershed.

Prothorax with side and coxa blue, the blue extending up on dorsal surface on posterior third of middle lobe: dorsal surface light brown except the darker middorsal line, the area between the two horns, and the apices of the horns which shade into dark brown and black.

Pterothorax (compare with fig. 20 of paratype male) with mesostigmal lamina and antealar sinus black, between them a broad black middorsal stripe either half of which covers the inner half of a mesepisternum; lower half of mesepisternum pale blue, this pale stripe wider at upper end where below the antealar carina, it encroaches on the middorsal black stripe, and on the upper posterior angle of the mesepimeron. Mesepimeron dark brown, which broad stripe extends across upper two-thirds or three-fourths of mesinfraepisternum. Upper three-fifths of metepisternum is a pale blue stripe which above (posterior end) curves down entirely across the sclerite, and below (anterior end) extends across upper third of metinfraepisternum. Both coxae blue. Metepimeron pale blue with a narrow stripe along its lower edge. Ventral surfaces pale blue with a jet black spot between fore coxae and a second and larger black, midventral spot between the middle and hind coxae. Legs pale tawny with "knees" and tarsi darker. Wings hyaline with veins and stigmas black.

Abdomen with sides of seg. 1 pale blue, a narrow apical ring and dorsum dark. Seg. 2 with sides less distinctly blue, dorsum and apical ring dark brown. Segs. 3–7 dark brown above and on posterior sixth of segment; a basal ring and lower sides yellow. Segs. 8–10 black on dorsum and upper sides, paler (yellow?) on lower sides. Superior appendages black; inferiors pale.

Structure. Labium (as in female, fig. 17) with a rectangular apical notch, the width of whose bottom equals length of either side of notch. Frons (as in female, fig. 18) broadly rounded between vertical and horizontal surfaces (no transverse frontal keel or angle as in some Heteragrions).

Prothorax. (Compare with figs. 5–7 of a paratype male). Middle lobe with a sharply and deeply impressed middorsal area (figs. 6 and 7). Posterior lobe enormously developed into a divided apron, either half of which spreads over a "shoulder" of the pterothorax, and the anterior,[1] inner angles of which are produced upward into a pair of large prothoracic horns.

Pterothorax with a simple mesostigmal lamina (fig. 8) and otherwise unspecialized (fig. 20 of a paratype).

Wings (check on fig. 1 of a paratype), length from base to nodus 3.25 times in total length: greatest width in length, f. wg. 5.8 times,

[1]Similar lobes on the prothorax occur in some of the species of Papuagrion from the region of New Guinea. See Lieftinck, 1937, Nova Guinea (New Series), vol. 1, fig. 25, *P. laminatum* Lftk., fig. 27, *auriculatum* Lftk., fig. 29, *fraterculum* Lftk.

EXPLANATION OF FIGURES 5–13

Archaeopodagrion bicorne n. gen., n. sp. Male from Guama Yacu, Oriente, Ecuador, November 9, 1935.

5–7. Prothorax. 8. Mesostigmal lamina. 9–11. Apical appendages of male. 12–13. "Penis."

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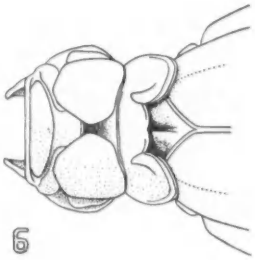

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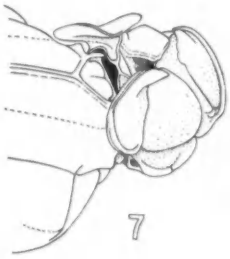

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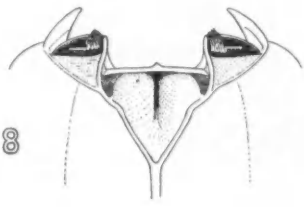

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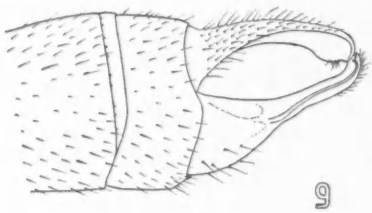

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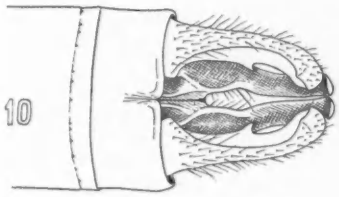

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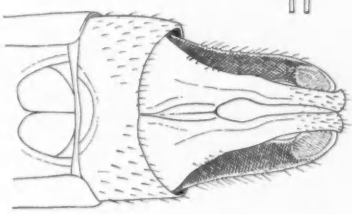

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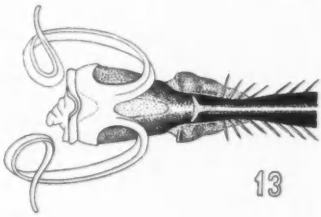

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h. wg. 5.4 times: petioled to middle level of quadrangle. Stigmas long, two subtend 2 R_1 cells, one subtends 2.5 cells and one 3 cells; width 2.7–3 times in length of anterior side: ends slightly oblique: a light-weight brace vein. Antenodals 2. Arculus distinctly beyond second antenodal. Postnodals 17 and 16, f. wgs., 15 and 14 in hind wings. M_2 arises at level of p. n. 9 in fore wing and at 8 in hind wings. M_{1a} arises two cells distant from origin of M_2 in three wings and one cell distant in one wing. Rs arises distad of subnodus a distance equal to length of subnodus (Munz, 1919, fig. B, p. 7): M_3 arises twice as far before the subnodus. All veins in smooth courses from base to tip except apices of M_4 and Cu_2. (The fore wing of fig. 1 is exceptional in having the outer courses of M_1 and M_{1a} zig-zag.) In fore wing two postquadrangular M_4 cells, in hind wing one. (This is exceptional: in all other wings in the material there are two such cells as in figs. 1 and 2.) Quadrangle long and narrow, widening distally, its outer side oblique. Fore wing, quadrangle with outer side 2.5 times in anterior side, 3.3 into posterior side; inner end 6 times in length of anterior side. Hind wing, quadrangle with outer side 3 times into anterior side, 4 times in posterior side; inner end 7 times into anterior side. Apex of Cu_2 at a level between origins of M_2 and M_{1a}.

Legs with apex of femur reaching base of abdominal segment 2. Spines slender, length two times the interspaces.

Abdomen moderately slender, enlarging rapidly from base of seg. 7 to apex of seg. 8. Seg. 10 twice as high as long. Seg. 2 with flat shelf-like posterior hamules. (See fig. 21 of a paratype male.)

Penis (described from a paratype) shown in figs. 12 and 13. It has no discoverable inner lobe which is lacking as in Heteragrion and Philogenia. The apical segment is deeply bifurcate, the two terminal lobes so-formed are long and slender (as in Allopodagrion[2], Heteragrion and Philogenia). Penis shaft with a single row of spinous hairs on either side (as in most Agriid Zygoptera). The penis drawn appears to have a spermatophore stuck to its posterior bend.

Appendages of seg. 10 twice as long as seg. 10, the inferiors slightly longer than the superiors (fig. 9). Superiors from above simply forcipate with a small internal spine slightly beyond midlength: apex rounded spatulate. In side view of dried holotype the tips are bent down more than in fig. 9. Dorsal and outer surfaces hairy: a short, inconspicuous, transverse keel on dorsal surface of apex (fig. 10). Inferior appendages in no wise shrivelled or degenerate as in most species of Megapodagrion and

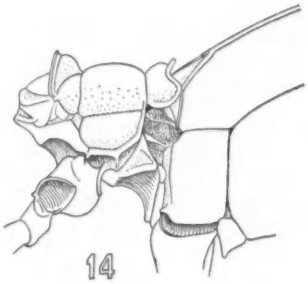
[2]From a male in Williamson Collection, University of Michigan, labeled *Megapodagrion contortum* = Allopodagrion Foerster; collected Porto Catherina de Santa Leopoldina, Brazil. Det.?

EXPLANATION OF FIGURES 14–21.

Archaeopodagrion bicornie n. gen., n. sp.

Figs. 14–19, female *allotype*, Rio Anzu, Partidero, Oriente, Ecuador, February 8, 1936. 14–16. Prothorax. 17. Labium and maxillae (spinous hairs omitted). 18. Face showing rounded frons and color pattern. 19. Abdominal segments 8–10.

Figs. 20–21. Male, as above from Rio Guama Yacu, Nov. 9, 1935. 20. Thoracic color pattern. 21. Second abdominal segment showing the flat, shelf-like posterior hamules and bag-shaped "seminal vesicle." The apex of the penis is omitted.



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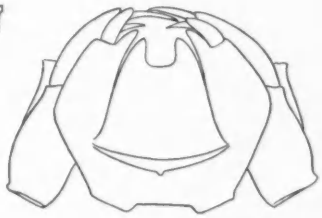

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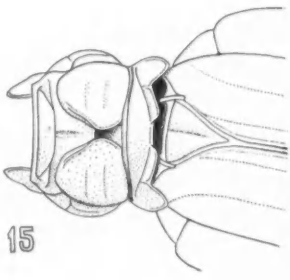

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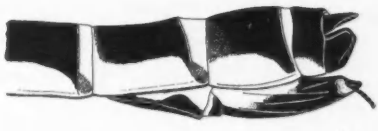

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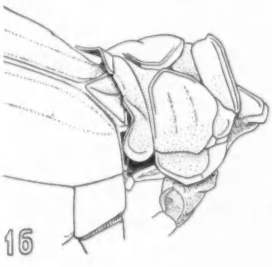

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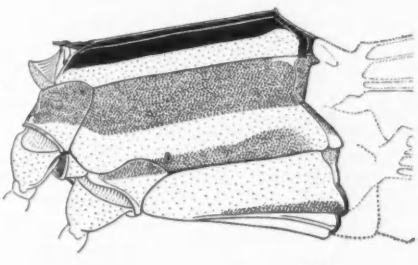

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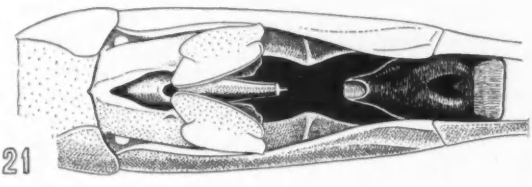

21

Heteragrion. They are slightly longer than the superiors with up-turned apices, are strap-shaped with the flat sides up and down. The bases of the inferiors lie so close together that they appear fused and may be so (figs. 10 and 11).

Described from *holotype* male collected by Wm. Clarke-Macintyre, Esq., on or near the Rio Napo at Napo, Oriente, Ecuador, December 12, 1935.

Allotype, female, color. Labrum orange, irregularly edged above with black (fig. 18). Ante-clypeus pale (yellow?), post-clypeus black with a pair of dumb-bell-shaped pale spots. Frons, vertex, occiput and under surface of cranium black, except for a minute brown spot ectad of each paired ocellus. Genae and exposed lateral bases of mandibles pale blue. Labium and bases of maxillae yellow with movable hooks jet black. Antennae dark brown.

Prothorax (dried material!) brown above except for black on middle third of posterior lobe. Lower sides and coxae pale blue which color extends up the posterior third of the middle lobe almost to middorsal line. The outer thirds of the hind lobe show bluish tints when wet. A jet black sternal spot between fore legs.

Pterothorax with mesostigmal lamina (fig. 15) black, this color continued to the black antealar sinus as a middorsal line the width of which equals one-third the width of a mesepisternum. The middorsal black stripe is bordered on either side by a dark redish-brown stripe of width equal to it. Outer half of mesepisternum pale blue. Mesepimeron brown, which stripe runs forward over upper two-thirds of mesinfraepisternum. Metathorax pale blue on side except an illy defined pale brown stripe covering roughly the posterior or lower half of metepisternum which brown stripe runs forward across upper third of metinfraepisternum. Coxae pale blue. Ventral surface blue except a jet black sternal spot between bases of middle and hind legs. Legs pale brown with brownish black "knees" and tarsi. Wings hyaline with black veins and stigmas, the latter dark brown under magnification.

Abdomen yellow and black as follows: seg. 1 with dorsum and narrow apical ring black; seg. 2 with apical third and dorsum dark; segs. 3 to 7 with dorsum and apical fifth of segment dark, a narrow basal pale (yellow) ring interrupted above, and lower sides yellow; seg. 9 similar but with no pale basal ring (fig. 19). Seg. 10 black except lower side. Superior appendages and paraprocts black. Sternite of 7 and ovipositor sheaths mottled black and yellow. Stylets black.

Structural characters, female. Head as in male.

Prothorax. (Figs. 14–16.) Middle lobe with a sharply and deeply impressed middorsal area (figs. 15 and 16) as in the male (figs. 6 and 7): posterior lobe divided medially but less developed than in male as it has no horns and from the side lacks the appearance of a shoulder cape (fig. 14). From above, the posterior half or flange of the posterior lobe is bilobate by the lack of any carina or flange along the hind edge of the middle fifth of the body of the posterior lobe (fig. 15). The inner half of each "flange" lobe is a low carina, the outer half is a thin orbicular area (fig. 16).

Pterothorax as in male. Wings shown in fig. 2. Length from base to nodus 3.5 times in wing length: greatest width 5 times in length: wing petioled to middle level of quadrangle. Stigmas long, width 2.6 into length of anterior side, slightly oblique, subtending 2 R_1 cells, posterior side slightly convex. Antenodals 2: arculus distinctly beyond second antenodal. Postnodals, fore wings 15 and 16, hind wings 13 and 14. M_2 arises in fore wings at 9 (r.) and 8 (l.), in hind wings at level of postnodal 7. M_{1a} arises 1 to 2 cells beyond origin of M_2. Rs arising just beyond level of subnodus in hind wings and 3 to 4 times as far out in fore wings. M_3 arising half the length of one postnodal cell before subnodus. All veins in virtually smooth courses from base to apex, except the tip of M_1 beyond stigma, the outer sixth to fourth of M_4 and the outer two-fifths of Cu_2. Two M_4 postquadrangular cells. Quadrangle long and narrow with sharply sloping outer side. Fore-wing quadrangle with outer side 2.3 times in length of anterior side, 3 times in posterior side; inner end 7 times in anterior side. Apex of Cu_2 at level of origin of M_{1a} (h. wg.) or one cell beyond (f. wg.).

Legs as in the male (male legs, figs. 3–4) with slender spines twice as long as interspaces: apex of femur reaching to base of abdominal segment 2.

Abdomen noticeably uniform in diameter from end to end except the slightly smaller seg. 10 and the added ovipositor and enlarged sternal region of segs. 8 and 9. Apex of abdomen crushed but probably correctly portrayed in fig. 19. Cerci as long as seg. 10 and slightly concave on lower surface. Paraprocts large, as long as cerci and flattened on outer surface. (These are so displaced by the injury to apex of abdomen that their size is uncertain. They may be squeezed caudad.) Apex of ovipositor on level with apices of cerci. There are no teeth along lower edges of ovipositor valves (as in some species of Heteragrion).

Described from *allotype* female collected by Wm. Clarke-Macintyre, Esq., at Partidero on the Rio Anzu, February 8, 1936.

Paratypes consist of 3 males, some data on which are as follows: one male, from Canelos on Rio Bobonaza which flows into Rio Pastaza, Prov. del Oriente, Ecuador, December 12, 1938; two males collected on the Guama Yacu, a branch of the Rio Anzu near El Partidero, November 9, 1935, by Wm. Clarke-Macintyre. In these abd. is 31–32 mm., hind wing 20.5–22.5 mm. Postnodals vary from 15–16 in fore wing and from 13–14 in hind wings. M_2 arises at level of postnodal 8 or 9 in fore wing, more often at 8; and at level of postnodal 6 or 7 in hind wing, more often at level of 7. Postquadrangular cells usually two in number (but see hind wings of holotype).

THE PHYLOGENETIC POSITION OF ARCHAEOPODAGRION

In the writer's mind this genus is with little doubt close to Megapodagrion and even closer to Allopodagrion as represented

by *contortum* (Selys). The characters of the penis place it without question in the Megapodagrion, Allopodagrion, Heteragrion, Oxystigma, Philogenia group of South American Megapodagrionine Odonata. Its wings are those of a Megapodagrion (*sens lat.*) which has never had extra sectors other than M_{1a} or has lost a few such. It fits the South American picture of evolving Megapodagrionine dragonflies better to have had no extra sectors other than M_{1a}.

(This discussion is from the writer's point of view that: "The primitive Zygopter must have been a small insect no larger (if as large), than Ortholestes, Miocora, Argiolestes or Micromerus that had a reduced venation, in which there were probably but two antenodals, in which M_3 and Rs arose near the subnodus, in which there may or may not have been a few more extra sectors than M_{1a}." Kennedy, 1920, p. 20.)

The species coming from South America looks so much like a Heteragrion or similar member of this group of genera that we are finding our specimens among the hundreds of unsorted Heteragrions. Both genera have smooth veins. Archaeopodagrion does not have the size or structural or color peculiarities of Megapodagrion or Philogenia. The single specimen inspected roughly at an earlier date bore the label "n. gen. near Heteragrion," this because of the size (though slightly small for Heteragrion), the smooth courses of the veins, the conspicuous stigmas and long spines on the legs.

We were still puzzled at its apparent relationship to Heteragrion until we examined the penis. This organ has the peculiarities of the penis in Megapodagrion and Allopodagrion except it is not as extremely specialized in: 1. the enormous development of the inner lobe in Megapodagrion and in Allopodagrion and; 2. the splitting of the terminal segment to its very base as in the latter genera. (See Kennedy, 1920, figs. 115–118.) It resembles these genera in having slender apical lobes directed caudad. It resembles the Heteragrion penis (l. c. figs. 123–124) and the Philogenia penis (l. c. figs. 113–114) in having little or no internal fold. It differs from the penis of Heteragrion in that the latter penis has the terminal segment not so deeply cleft and the resultant filaments extended ectad. In Dimeragrion they are similar but folded back (l. c. figs. 119–120). The penis of Archaeopodagrion is intermediate in its characters between the group of genera comprising Heteragrion and Oxystigma, the group, less compact, comprising Dimer-

agrion and Philogenia and the group composed of Megapodagrion and Allopodagrion. In penis characters it is closer to Allopodagrion than to Megapodagrion, is closer to Philogenia than to Dimeragrion or Heteragrion.

The wings in all characters except extra sectors and the long stigma resemble Allopodagrion. As Allopodagrion has considerable reduction in extra sectors it resembles it again rather than Megapodagrion. The smooth courses of the veins give it a resemblance to Heteragrion but their origins suggest Philogenia and Dimeragrion. (The curious Megapodagrionine genera, Thaumatoneura and Paraphlebia, from Mexico and Central America, do not enter the discussion. Their penes—Kennedy, 1920, Pl. III—show that their relationships are with the Megapodagrionine stock of eastern Asia and the East Indies. They have entered the Neotropics over the Alaskan land bridge.)

From this point of view Archaeopodagrion is a very generalized and primitive form which lies at the base of the Megapodagrionine family tree and among South American forms has stem characters which relate it on the one hand with Allopodagrion and Megapodagrion and on the other hand with Philogenia, Dimeragrion and Heteragrion. The high specialization of the male prothorax is the type of structure so frequently found in very old living forms. It is a Podagrion ghost out of the past.

SIGNIFICANT LITERATURE REVIEWED ON AMERICAN MEGAPODAGRIONINAE

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THE FULGORINA OF BARRO COLORADO AND OTHER PARTS OF PANAMA, by Dr. Z. P. Metcalf. Bulletin of the Museum of Comparative Zoology at Harvard College. Vol. LXXXII, No. 5. pp. 275–423 with 23 plates. 1938.

In this paper Dr. Metcalf has presented an extended survey of the Fulgorina of the Panama region including many keys and descriptions of a number of new species with references to earlier descriptions. (Sixteen genera and forty-one species are described as new.) He has given particular attention to location of genotypes and the article is very fully illustrated with original figures. There is also an extended bibliography. For the most part he has retained the nomenclature of recent workers and the most revolutionary change appears to be concerning the group Delphacidae for which he substitutes the family name Araeopidae. The basis for this change is stated to be that the name Delphax is preoccupied in Mammalia.

The illustrations are excellent and especially in the numerous figures of genitalia which appear to have been drawn with special care there will be an excellent foundation for further studies of the genera treated. Dr. Metcalf is to be complimented on the quality of the article and the Museum on the excellent typography and printing.—Herbert Osborn.

SIGNIFICANCE OF THE PRESYSTOLIC NOTCH IN THE MECHANOCARDIOGRAM OF PERIPLANETA AMERICANA (L.)

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It has been shown that the mechanocardiogram of the American cockroach (*Periplaneta americana* (L.)) frequently exhibits a presystolic notch (*1*).[1] This is illustrated in Figure 1, in which the rise of the curve (*A*) represents cardiac systole, the descent of the curve (*B*) represents diastole, and *C*, *D*, and *F* are presystolic notches. In these experiments the connection of the heart lever was with the ventral surface of the dorsal diaphragm of the inverted isolated heart preparation at a point just over the heart. See (*1*) and (*2*) for details of the methods used. Thus any force that will result in a fall or rise of the dorsal diaphragm at the point of lever attachment will produce at the same time an ascent or a descent, respectively, of the curve. The presystolic notch does not occur invariably and may not always be of the same magnitude, even in a single recording from a single isolated heart preparation (compare *C* and *E* in figure 1).

In seeking an adequate explanation for its occurrence, several possible causes deserve consideration. Briefly stated, they are (1) presystolic contractions (twitches) of the alary-muscle fibers of the heart and of the dorsal diaphragm, (2) presystolic relaxation of the cardiac muscle fibers, (3) presystolic contractions of the dorsal body muscles, and (4) a presystolic increase of intracardiac hydrostatic pressure in the region of the heart exhibiting the notch. Some of these factors (1, 3, and 4) have received tentative consideration elsewhere (*1*, *2*). In this paper evidence is presented which indicates that the presystolic notch is produced by an increase of intracardiac pressure.

EXPERIMENTAL EVIDENCE AND INTERPRETATION

The evidence, obtained at various times, supporting this explanation can be briefly stated in the following paragraphs:

Contractions of dorsal body muscles. It has been found (2) that, upon application of strong electrical stimuli, contractions of the dorsal body

[1]Italic figures in parentheses refer to Literature Cited, p. 48.

muscles accompanying cardiac extrasystoles can produce deflections of the curve that simulate presystolic notches. Comparison, however, of the spontaneously occurring presystolic notch with that produced by the stimulated dorsal body muscles shows that they are not identical in form. It is hardly to be expected that the dorsal somatic muscles give rhythmic twitches synchronously with the heart beat and timed so exactly in accordance with cardiac systole. The results of these experiments indicate, therefore, that contraction of the dorsal body muscles can be eliminated as the cause of the presystolic notch.

Stimulation of alary-muscle fibers. Presystolic contractions (twitches) of the alary-muscle fibers can be tentatively eliminated as a cause of the presystolic notches, in view of the fact that efforts to stimulate electrically the alary muscles to contract have thus far completely failed (2). No evidence of contraction could be detected in them when

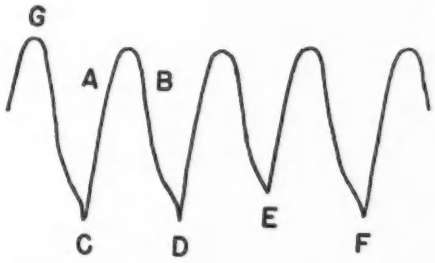

Fig. 1. Tracing of part of a mechanogram taken from an entire isolated heart preparation of *Periplaneta americana* (L.). Lever attachment was in second abdominal segment. Upstroke of curve (*A*) is systole and downstroke (*B*) is disatole. Diastasis does not appear. Rate of pulsation was approximately 60 per minute. Heart preparation kept moist with modified Levy's saline solution (1, 2). Vertical height of original record from *C* to *G*, 4 cm. Presystolic notches occur at *C*, *D*, and F. At *E*, where systole follows diastole more quickly, the presystolic notch does not occur. Room temperature.

they were observed microscopically during stimulation. Thus far no mechanocardiogram has yielded evidence that they contract. Mechanical stimuli have failed to produce evidence of alary-muscle contractions in this insect. No conclusions regarding contractions of the alary-muscle fibers could be arrived at on the basis of observations of the spontaneously contracting heart in isolated preparation. Tzonis (3), after making microscopic observations of the functioning heart, concluded that the alary-muscle fibers in *Corethra plumicornis* F. larvae do not contract.

Presystolic relaxation of cardiac muscle. Although the presystolic notch indicates that a presystolic dilation of the cardiac tube frequently occurs, there is no evidence as yet of an increase in functional relaxation just prior to contraction. On the basis of what is known regarding the physiology of muscular contraction, such a presystolic increase in the degree of cardiac relaxation is not to be expected. For the present, at

least, this factor can also be discarded as a probable cause of the presystolic notch.

Complete isolation of single segment. The presystolic notch occurs frequently when the entire isolated heart preparation (thoracic plus abdominal parts), the whole abdominal heart preparation, or a preparation including several abdominal segments together is used, but it has not yet been obtained when the heart preparation consisted of only a single abdominal segment completely separated by transaction from adjacent anterior and posterior segments (1, 2). These results indicate that the muscle fibers in such an isolated segment do not produce the notch, that more than a certain minimum length of cardiac tube must be functioning as a morphological whole in order for the presystolic notches to be produced, and that the minimum length of cardiac tube is greater than that lying between a single pair of alary muscles. The cause of the presystolic notch would thus seem to lie in some region of the heart other than that from which the mechanogram is being recorded.

Transection of alary-muscle fibers. If, in an entire isolated heart preparation or in a whole abdominal heart preparation, the distal attachments of the alary-muscle fibers in a given abdominal segment are broken, or if these alary-muscle fiber groups are severed across their middles, just lateral to the heart but without injury to the cardiac tube itself, the heart will undergo a sustained contraction and its diameter in that segment will become greatly reduced. Under proper experimental conditions the pulsation of the heart as a whole will not cease and the propagated wave of heart beat will pass through the affected segment. If a preparation is obtained in which the wave of heart beat is sufficiently slow so that it appears to the eye (observing microscopically) definitely as a propagated contraction wave, it can be seen that the cardiac tube dilates slightly each time the wave passes through the segment in which the alary-muscle fibers are cut. This dilation appears to be passive with regard to the cardiac tube and such as would be expected were the cardiac tube dilated by an increase of hydrostatic pressure that is caused by and occurs ahead of the propagated wave. The contracted cardiac tube in the effected segment could be seen to take little or no part in the movements involved in the heart beat other than this observed dilation. These observations indicate, as is to be expected, that the propagated cardiac contraction is associated with, and probably preceded by, a sudden, slight, and reversible increase of hydrostatic pressure, i. e., of blood pressure in the intact insect or of physiological saline pressure in the perfused isolated heart preparation.

Mechanocardiograms from point of origin of heart beat. The usual point of origin of cardiac contraction in the perfused isolated heart preparation is at the posterior end of the heart or, during reversed beat, at the anterior end. Fortunately, however, one entire isolated heart preparation was obtained, in which, for reasons unknown, the heart beat could be seen microscopically to originate in the fifth abdominal segment. From this point of origin waves of contraction progressed simultaneously both anteriorly and posteriorly. The wave propagated anteriorly eventually reached the severed aorta in the neck region of the beheaded preparation, and the liquid being forced anteriorly escaped

there. But the posterior end of the heart apparently offered an inadequate outlet, for it could be observed to dilate considerably when the posteriorly moving contraction wave approached and reached it.

Mechanocardiograms were taken from the point of origin of the heart beat (fifth abdominal segment). A tracing of a portion of this record is

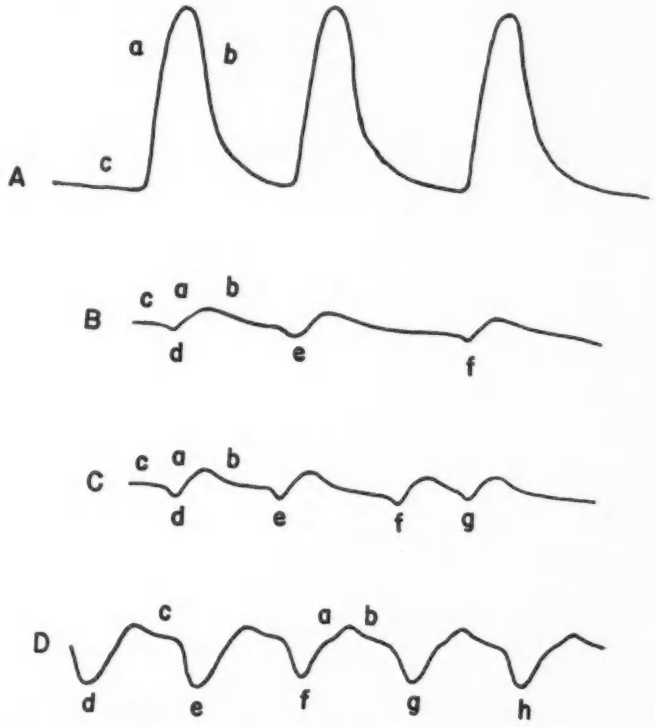

Fig. 2. Tracings from mechanograms taken from an entire isolated heart preparation of *Periplaneta americana* (L.). Lever attachments were in the fifth abdominal segment (*A*), near the anterior end of the abdomen (probably in second abdominal segment) (*B*), in the third thoracic segment (*C*), and at the posterior end of the heart (*D*). In each tracing *a* is systole, *b* is diastole, *c* is diastasis, and *d*, *e*, *f*, *g*, and *h* are presystolic notches. Room temperature. Heart preparation kept moist with modified Levy's saline solution (1, 2). Vertical contraction height in original record of tracing *A* approximately 4 cm.

shown in Figure 2, *A*. No presystolic notch occurs in the curve. In Figure 2, *B* and *C* are tracings of records obtained at points anterior to the fifth abdominal segment, and *D*, of records obtained at the posterior end of the heart. Because of accidental breaking of the lever tip, curves *B* and *C* were made with shorter lever than were *A* and *D*. Otherwise,

curves *B* and *C* would be higher than *D* and probably slightly lower than *A* (1). In *B*, *d*, *e*, and *f*, and *C*, *d*, *e*, *f*, and *g*, the presystolic notches are prominent, and in *D*, *d*, *e*, *f*, *g*, and *h*, the downward deflections, representing the presystolic notches, are the major deflections of the record. These records are such as can be expected on the basis of the microscopic observations just described. Actually the peculiarities of these mechanocardiograms led to the rather detailed microscopic observations that were made with this preparation.

From this experiment it can be concluded that in this heart preparation the presystolic notch does not occur at the point of origin of cardiac contraction, or that region of the heart that contracts earliest, but does occur in other regions of the cardiac tube, that is, in those regions that begin to contract after systole has already begun in another region. In view of the other observations and experimental results that have been mentioned, which were made at various times upon a number of isolated heart preparations, it is very probable that these conclusions apply generally to the other heart preparations from this insect. Thus, the presystolic notch does not occur in the record taken at the point of origin of the heart beat and does not occur in the record from the completely isolated single segment, which necessarily acts as its own point of origin of heart beat. It is conceivable that, if all regions of the cardiac tube should begin their systolic contractions simultaneously, presystolic notches would not appear no matter from what point the mechanocardiogram were taken. Similarly, failure of the notches to occur might be expected when the rate of propagation of heart beat and the wave length of the propagated contraction are sufficiently great to render the contractions of the various regions of the cardiac tube approximately simultaneous.

CONCLUSION

From the evidence presented it can be concluded that the presystolic notch of the mechanocardiogram of the cockroach *Periplaneta americana* (L.) is caused by an increase in pressure of the liquid inside the cardiac tube at the point from which the record is being taken, and that the increase of pressure is produced by cardiac contraction occurring in another region of the heart. There is no evidence that the presystolic notch is produced by contractions of the alary-muscle fibers, contraction of the dorsal muscle fibers, or presystolic increase in functional relaxation of the cardiac muscle fibers.

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APPARENT NUCLEAR-CYTOPLASMIC TRANSFER IN SOME INSECT BLOOD CELLS

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In an existent study of the blood picture of the southern armyworm, *Prodenia eridania* (Cram.), to be eventually utilized in an investigation of the effects of certain experimental procedures and toxic substances upon this insect, it has been necessary to make detailed microscopic observations with high magnification of the various blood (hemolymph) cell types. It has been observed frequently that the nuclei of certain blood cells present peculiar appearances which can be interpreted to indicate the occurrence of a transfer of material from nucleus to cytoplasm and, in some cells, even of a nucleus-to-cytoplasm-to-plasma transfer. Whether the transfer is a nuclear budding or an extrusion of nuclear or nucleolar material is not distinguished in this paper, and "nuclear to cytoplasmic transfer" is used with the general meaning of any process that results in the location of small masses of nuclear material in the cytoplasm of the same cell. This appearance has been encountered with sufficient frequency in the blood of southern armyworm larvae to justify its description.

METHODS

The methods of preparing the blood cells for study were to fix the insects with heat, to prepare blood smears, and to stain the latter. Heat fixation was accomplished by immersing the living insect in water hot enough (60° C. for 5 minutes for southern armyworm larvae) to fix the cells completely without causing a plasma protein precipitation. The animal's blood was then sampled, smeared, and stained by the modified Wright's technique (Wright-nicotine-oxalic acid technique), a detailed description of which has been reported elsewhere (Yeager, 1938). Smears of heat-fixed blood from larvae of the southern armyworm were subsequently treated with acetic corrosive sublimate for 3 minutes and then treated according to the Feulgen (Lee, 1928) technique, which is generally used as a test for chromatin, although actually it is a micro-chemical test for aldehyde groupings derivable from thymonucleic acid usually present in the chromatin of animal cells.

RESULTS

The blood of southern armyworm larvae stained by the Wright-nicotine-oxalic acid technique (Yeager, 1938) contains cells that frequently exhibit nuclei with marked unevenness of contour, which may vary from a fairly even nuclear contour approximating that most frequently observed in the blood cells of this insect to a condition in which conspicuous masses of material may seem to extend from the nuclear surface out into the perinuclear cytoplasm. In some cells detached masses of material can be seen in the cytoplasm, particularly in the perinuclear region. These masses are of the same color and texture as the intranuclear chromatic masses and, even when seen hazily in the depths of a thick layer of very basophilic cytoplasm, can be seen to be chromatically related to the nuclear chromatin.

Plate I, figures 1–4, are photographs of cells exhibiting this appearance. Figure 1 shows a cell with deeply basophilic cytoplasm that obscures the nucleus, but what appears to be a chromatin mass (*a*) can be detected on the left. This photograph shows the limits of the cell which, like practically all of the cells of armyworm blood smears treated in this way, has retained its circulating quiescent form (Yeager, 1938) and displays a considerable depth or thickness. Plate I, figure 2, is a photograph of the same cell printed on a contrasty paper, which shows less distinctly the cell boundary but much more distinctly the irregularity of nuclear contour and, on the left, the chromatin mass (*a*) apparently at the point of detachment from the nuclear surface. On the left and right appear two other masses (*b*, *c*) that appear to be in the process of formation. Plate I, figure 3, corresponding to figure 1, shows the relatively inconspicuous limits of a cell the cytoplasm of which appears to contain much material (*a*) that stains like the chromatic masses of the nucleus. In Plate I, figure 4, which corresponds to figure 2, the nucleus (*b*) and the cytoplasmic contents (*a*) can be more clearly distinguished. In the cells of Plate I the cytoplasm was stained a deep grayish blue and contained a number of clear, unstained vacuole-like inclusions, some of which (*d*) can be faintly distinguished in the peripheral cytoplasm of Plate I, figure 2, as rather light areas.

Plate II contains some camera lucida drawings of several of the numerous cells in which this appearance has been observed. In these drawings the main outline of the nucleus has been represented by a fairly regular line which gives to the main body of the nucleus a smoother contour than it actually possesses, since the chromatic masses located at the periphery of the nucleus usually give to the nuclear contour a moderately fine and consistent irregularity. The main protruding and apparently extruded masses are represented in solid black, as are the larger chromatic masses of the nucleus. The fine broken or unbroken lines represent the more conspicuous cytoplasmic structures (such as colorless vacuoles or crystals; see Plate II, *A*, *a*) other than the chromatinlike masses under consideration. In Plate II, *C*, several of these masses (*a*, *b*, *c*, *d*, *e*) can be seen apparently being extended from the nuclear surface into the perinuclear cytoplasm. In Plate II, *B*, similar projecting masses (*a*, *b*, *c*, *d*) can be observed and, in addition, two small masses (*e*, *f*), completely detached from the nuclear membrane, are

visible. Similar conditions can be seen in Plate II, *A*, *G*, and *E*. In *E* the detached masses are more numerous, are conspicuously elongate, and are not confined to the perinuclear region of the cytoplasm. In Plate II, *F*, the cell body is pear-shaped and the cytoplasm contains masses that stain like the chromatic masses of the nucleus but are of elongate form. These elongate masses appear sometimes with (as in Plate II, *F*, *a*) and sometimes without varicosity-like irregularities. In Plate II, *D* is shown a cell without obvious protrusion of masses from the nuclear surface. The cytoplasm contains a number of large elongate masses (*a*) that stain similarly to the nucleus but present a somewhat different texture. They often appear rigid and are somewhat suggestive of crystals. These are found most often in oenocytoids.

In all of the southern armyworm cells depicted and in nearly all of those studied the chromatic masses of the nucleus and the protruded and apparently extruded masses that have been described are markedly eosinophilic, whereas, the cytoplasm is usually basophilic. Only occasionally has eosinophilic cytoplasm been observed and then usually in the oenocytoid. The degree of cytoplasmic basophilia is variable from one cell type to another, the color ranging from a nearly neutral gray to a deep grayish blue.

The Feulgen reaction was used to indicate whether the protruding and apparently extruded masses contained chromatin material or whether they consisted of non-nuclear material that happened to show nuclearlike chromatic reactions with the modified Wright's technique used. In the Feulgen-stained blood smears the same phenomena were observed. Masses of nuclear material were seen to protrude from the irregular nuclear surface and detached masses of similarly staining material were observed to lie both in perinuclear and peripheral cytoplasm. In general, nuclear contours appeared more ragged with the Feulgen than with the Wright-nicotine-oxalic acid technique.

DISCUSSION

The nuclear origin of the described protruding and detached masses is indicated by (1) the fact that cells can be found showing a series of conditions from one or two protruding masses through intermediate conditions of a few protruding and one or two perinuclear detached masses to a condition of perhaps some protruding masses and a considerable number of perinuclear and peripheral detached masses, and by (2) the fact that with both the Wright-nicotine-oxalic acid technique and with the Feulgen technique the protruding and detached masses appear to be chromatically and texturally the same as the chromatic masses of the nucleus. According to the Feulgen reaction, both the protruding and detached masses and the nuclear chromatin contain thymonucleic acid as a constituent.

Although, so far as the author is aware, extrusion of chromatin or other nuclear material into the cytoplasm of the insect blood cell has not been reported heretofore, the transfer of material from nucleus to cytoplasm in certain other cells, particularly cells of a glandular nature, has been described by a number of authors. It is not intended to present here a complete survey of literature on the subject, but merely to

mention a few papers in which transfer of material from nucleus to cytoplasm has been reported.

Hufnagel (1918) described the transfer of material from nucleus to cytoplasm in cells of the hypodermis, the midgut, the imaginal rings of foregut and hindgut, the adipose tissue, and the nerve ganglia in the lepidopteron *Hyponameuta padella* L. She also described budding and detachment of peripheral nuclear masses in larval and imaginal oenocytes. Korschelt (1891, p. 15) reported finding nuclear to cytoplasmic transfer of material in *Dytiscus*. Maziarski (1910) studied cells in the digestive organs of several isopods, reported the transfer of chromatin granules from nucleus to cytoplasm, and claimed that chromatin dissolved in nuclear juice also passes into the cytoplasm of these cells. Maziarski (1911) investigated silk secretion in a number of insect larvae and concluded that nucleoli, either as discrete bodies or dissolved in nuclear juice, may be passed into the cytoplasm of the secretory cells and that, to a slight extent, nuclear chromatin may also be involved in the process. Ludford (1925, a) described nuclear budding and extrusions of nucleoli in the mouse epididymis during secretion. He also reported (Ludford, 1925, b) nucleolar extrusions into cytoplasm in the cells of mouse tar tumors. Macallum (1889–90), studying amphibian intestinal epithelial cells and pancreatic cells, reported the extrusion or migration of plasmasomata from nucleus to cytoplasm. Wilson (1928, p. 355) withheld final judgment on the question of yolk formation from extruded nucleoli because of conflicting evidence among both early and later workers, and with regard to the early oocyte he states that "the extrusion of nucleolar fragments x x x has been described so circumstantially and by so many observers that the question must at least be held open." Kinney (1926), in a study of the silk gland of *Hyphantria cunea*, reported that in the gland-cell nuclei large nucleoloid bodies appear to give rise to nuclear bodies which in turn are passed from nucleus into cytoplasm. References to other literature on the subject will be found in these papers and in Wilson's book. Although opinion is divided on the question of transfer of visible material from nucleus to cytoplasm, there is thus considerable evidence that it can occur, particularly when the extruded material is nucleolar in nature.

Extensive speculation on the probable significance of the nuclear to cytoplasmic transfer of material here reported in the case of blood cells of southern armyworm larvae would be futile, but several possibilities may be indicated. Explanations of this apparent transfer of material from nucleus to cytoplasm may fall into the following categories: (a) That the process is a morbid one, accompanying or antedating cellular degeneration; (b) that it is involved in the early stages of transformation of certain cells (which would correspond to thrombocytes) from the quiescent to the active state in the early stages of cell coagulation of the hemolymph; (c) that the transfer process is one of nuclear or cellular excretion or purification; (d) that it is involved in a secretory activity of the cell; or (e) that the detached masses are fragments of material originating by phagocytosis of cellular or tissue debris. Although it is not improbable that some of the numerous cells of the southern armyworm blood may function as circulating unicellular

glands (or that explanation (b) may apply), the correct explanation of these cytological observations must rest upon future investigation.

SUMMARY AND CONCLUSIONS

Heat-fixed smears of blood (hemolymph) from the larva of the southern armyworm, *Prodenia eridania* (Cram.), stained by the Wright-nicotine-oxalic acid and the Feulgen techniques, frequently possess cells the nuclei of which appear to protrude masses into the perinuclear cytoplasm and to extrude masses into the cytoplasm where they may occupy perinuclear and peripheral positions.

According to these techniques, the protruded and extruded masses are chromatically similar to the chromatin masses of the nucleus.

According to the Feulgen reaction, the nucleus and these protruded and extruded masses contain either thymonucleic acid or a related compound that behaves like it in this test.

Analogous observations made on certain cells of insect and other tissues have been reported in the literature, references to some of which are made.

The cytological or functional significance of these observations is not now known but several possible implications are listed.

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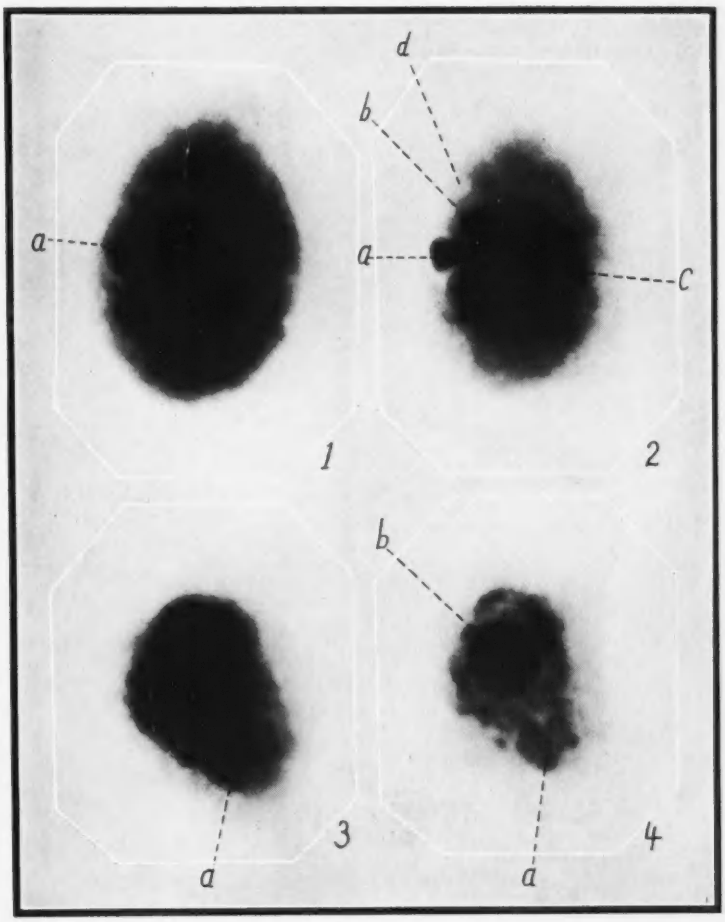
EXPLANATION OF PLATE I

Figures 1 and 2 are photographs of a larval southern-armyworm blood cell in which two protruding (fig. 2, *b* and *c*) and one apparently detached (fig. 1, *a* and fig. 2, *a*) masses of nuclear material are shown. From a Wright-nicotine-oxalic acid stained smear of heat-fixed larval blood. Nucleus and nuclear masses intensely eosinophilic and cytoplasm intensely basophilic (deep grayish blue). Figure 1 shows cell boundaries. The nucleus is obscured by basophilic cytoplasm. Figure 2, printed on paper of greater contrast, shows chromatin masses and nucleus more distinctly and cell boundary less distinctly. Magnification, about 1,500 ×.

Figures 3 and 4 are photographs of another blood cell from a larval southern armyworm, in which chromatin-like inclusions (fig. 3, *a* and fig. 4, *a*) and an eccentric nucleus (fig. 4, *b*) are shown. From a Wright-nicotine-oxalic acid stained smear of heat-fixed larval blood. Nucleus and cytoplasmic inclusions are intensely eosinophilic. Cytoplasm is decidedly basophilic. Figure 3 shows cell boundaries. Nucleus and cytoplasmic inclusions are obscured by basophilic cytoplasm. Figure 4, printed on paper of greater contrast, shows nucleus and cytoplasmic inclusions more distinctly and cell boundary less distinctly. Magnification, about 1,500 ×.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EXPLANATION OF PLATE II

Figure 5.—Camera lucida drawings of some larval blood cells of the southern armyworm that exhibit protruding nuclear masses, apparently detached nuclear masses and, in D, cytoplasmic inclusions of more doubtful relationship. From Wright-nicotine-oxalic acid stained smears of heat-fixed larval blood. The drawings, particularly of the contour and chromatin masses of the nucleus, are somewhat diagrammatic. Magnification is about 1,500 ×.

A. *a* is an intracellular crystal; *b* is one of the cytoplasmic vacuoles; *c*, *d*, and *e* are chromatinlike masses; and *f* is a chromatin mass of the nucleus.

B. *a*, *b*, *c*, and *d* are apparently masses of chromatinlike material protruding from the nuclear surface; *e* and *f* are detached masses in the perinuclear cytoplasm; *g* is a chromatin mass of the nucleus, and *h* is one of the cytoplasmic vacuoles.

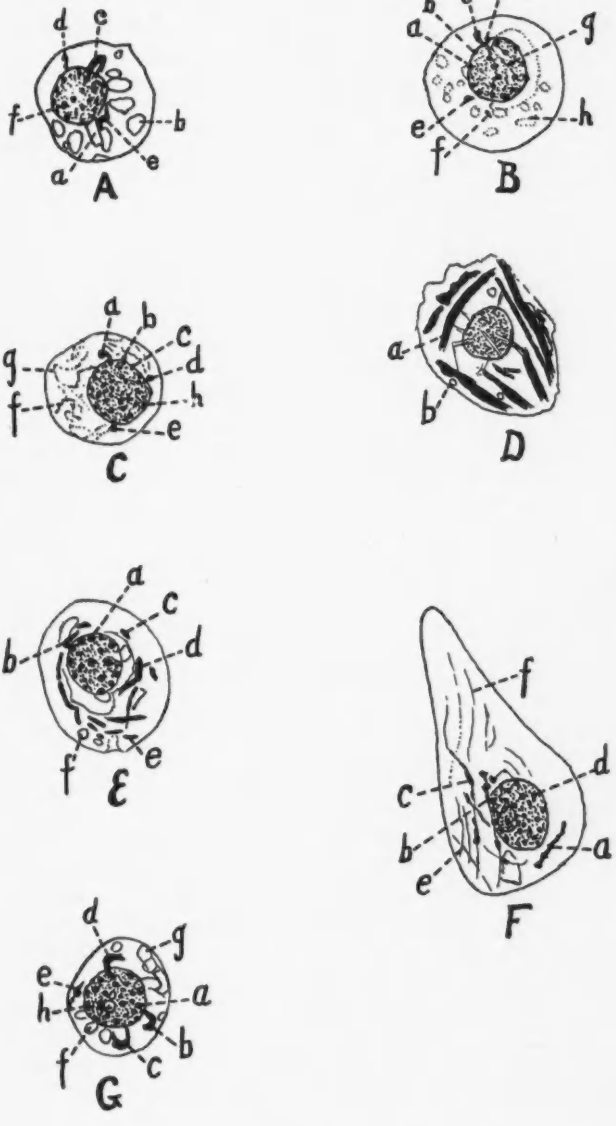
C. *a*, *b*, *c*, *d*, and *e* are apparently protruding masses of chromatinlike material; *f* and *g* indicate some of the channellated vacuolization seen in this cell; and *h* is a chromatin mass of the nucleus.

D. The chromatin masses of the nucleus are not represented, since none were apparently protruding. *a* is one of the cytoplasmic inclusions of doubtful relationship, although they are eosinophilic like the protruded and detached chromatinlike masses seen in the other cells. *b* is one of the cytoplasmic vacuoles.

E. *a* is a chromatin mass of the nucleus; *b* is an apparently protruding chromatinlike mass; *c*, *d*, and *e* are three of the detached chromatinlike masses; and *f* is a cytoplasmic vacuole.

F. A pear-shaped oenocytoid, *a* and *c* are detached chromatinlike masses; *b* is an apparently protruding chromatinlike mass; *d* is a chromatin mass of the nucleus; and *e* and *f* indicate what are suggestive of cytoplasmic lines of stress and strain or of flow (often observed in oenocytoids of this type).

G. *a* is a chromatin mass of the nucleus; *b*, *c*, and *d* are apparently protruding chromatinlike masses; *e* is a detached chromatinlike mass; and *f* and *g* are cytoplasmic vacuoles. *h* indicates a body characteristic of the nuclei of nearly all of the larval southern armyworm blood cells but not represented in the other drawings; this body is suggestive of Kinney's "nucleoloid body" in the complex nuclei of lepidopterous spinning gland cells.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ODYNERUS ANNECTENS DE SAUSSURE AND RELATED SPECIES, WITH ADDITIONAL NOTES ON ODYNERUS HIDALGO DE SAUSSURE

(Hymenoptera, Vespidae)

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The many North American wasps described as *Odynerus*, in the broadest sense, offer some baffling problems in taxonomy. One of these is the extraordinary variation in color, which led to a multiplicity of names for supposed "species." When attention will be paid more generally to structural characters, rather than to color patterns, this difficulty will be easily overcome. A much more knotty problem concerns the natural grouping of the structural species and the consequent breaking up of *Odynerus* into smaller units—genera or subgenera. Eventually, no doubt, groups will be defined that are both theoretically sound and practical. From several years' experience with numerous species, of all parts of the world, I venture the opinion that the time is not yet ripe for a rational arrangement of these wasps. In any case, I am convinced that any attempt at dividing *Odynerus* taking in account only the members of a limited fauna (as has been done recently by a German entomologist), is doomed to failure. It will create chaos and only hinder, not further progress. Nothing is easier, of course, than to pick out conspicuously distinct species and tag onto them generic or subgeneric names (in accordance with the so-called, arbitrary "Laws of Nomenclature"). Such a procedure, however, not only leaves out the many annectent species, but it also fails as a guide to a study of natural relationships.

Brushing aside for the moment purely nomenclatorial tangles (such as the irritating and rather futile question of the genotype of *Odynerus*), the crux of the matter seems to lie in the difficulty of deciding which character or combination of characters are fundamental enough to indicate true phylogenetic relationship. In the Eumeninae there are apparently few characters of this type, most of the structural specific differences being merely "shuffled" into various combinations, without suggesting well-defined lines of descent. Moreover, if occasion-

ally a character recurs in so many species that it appears to indicate natural kinship, upon further inquiry it may be found that it was acquired independently by unrelated ancestral stocks. As I have shown elsewhere (1925, Trans. Amer. Ent. Soc., LI, pp. 58–60), this seems to be the case with the transverse carina of the first abdominal tergite, the only characteristic of the "genus" *Ancistrocerus*.

The species discussed in the present paper offer another illustration of the same type of obstacle. Among the larger North American species which de Saussure grouped in his "Division *Odynerus*" (1875, Smithson. Miscell. Coll., No. 254, p. 247), but which I place in *Rygchium* Spinola, some have the first tergite smooth and almost devoid of puncturation (except occasionally at the extreme sides). Typical of these is the common and widely distributed *Odynerus dorsalis* (Fabricius). A few species of this type have, in addition, most of the second tergite impunctate, except for a narrow preapical zone of coarse punctures. This latter feature is most strongly marked in *Odynerus pratensis* de Saussure, which has the impunctate area of the second tergite quite polished. In a recent paper (1936, Proc. U. S. Nat. Mus., LXXXIV, pp. 80–87), I discussed this species, as well as a related form, called there *O. tempiferus* Viereck, but which is really *O. annectens* de Saussure, as shown in the sequel. At first glance, most of the second tergite of *O. annectens* also appears impunctate; but a closer study, with a high magnification, shows a few minute punctures widely scattered over the surface and gradually increasing in size and numbers toward the preapical zone of coarse sculpture. The first tergite also frequently shows a sprinkling of minute punctures, particularly over the convexity. This additional puncturation is somewhat more pronounced in *O. annectens* var. *eldoradensis* Rohwer, of the western (Pacific) States, than in the eastern varieties of the species. *O. annectens* is thus transitional in this respect between the group of *O. dorsalis* (with impunctate first tergite) and that of *O. rugosus* de Saussure (=*O. foraminatus* de Saussure) (with the first tergite punctate throughout). It seems, therefore, futile to use the puncturation of the first and second tergites to define subgeneric groups in *Rygchium*. Moreover, species of *Rygchium* with impunctate or nearly impunctate first or first and second tergites also occur outside North America (notably in the Ethiopian Region), and these are not in any way related to the group of *O. dorsalis*.

Dr. R. M. Bohart has recently sent me a third species of this group, with permission to describe it in this paper. This species is a further step in the direction of the group of *O. rugosus*, having the first tergite and the major part of the second densely covered with microscopic punctures, but devoid of larger puncturation.

KEY TO ODYNERUS ANNECTENS AND RELATED SPECIES

The three species considered in this paper may be separated as follows:

1. Lateral angles of propodeum prominent, broadly triangular, with sharp apices. Thorax short and thickset, less than one and a half times as long as wide seen from above. Humeral margin of pronotum with a low carina which is narrowly interrupted in the middle; dorsal lateral areas of pronotum evenly rounded into the vertical lateral areas. Concavity of propodeum roughly, transversely striate. Second tergite not polished. Second sternite with a prominent longitudinal furrow basally. Clypeus (♀ ♂) not wider than high, the apical margin slightly concave, with sharp edges.....**O. annectens**

Lateral angles of propodeum broadly and evenly rounded or flattened and ridge-like. Clypeus much wider than high in both sexes..... 2

2. Lateral angles of propodeum broadly and evenly rounded, not ridged; concavity of propodeum roughly, transversely striate. Thorax elongate, about one and a half times as long as wide seen from above. Humeral margin of pronotum raised into a high, sharp collar, continuous across the middle; dorsal lateral areas of pronotum divided from the vertical lateral areas by a ridge, which is particularly prominent and sharp at the humeral angle. Second tergite mostly polished (except for preapical zone of coarse punctures). Second sternite with a prominent longitudinal furrow basally. Clypeus (♀ ♂) nearly one and one-third times as wide as high, the apical margin straight, with blunt edges.....**O. pratensis**

Lateral angles of propodeum flattened into oblique, broad ridges; concavity of propodeum nearly smooth, the striae scarcely apparent. Thorax short and thickset, much less than one and a half times as long as wide seen from above. Humeral margin of pronotum with a low carina which is narrowly interrupted in the middle; dorsal lateral areas of pronotum evenly rounded into the vertical lateral areas. Second tergite not polished. Second sternite without distinct longitudinal furrow basally. Clypeus (♀ ♂) much wider than high, the apical margin slightly concave, with sharp edges.....**O. discogaster**

Odynerus (Rygchium) pratensis de Saussure

Odynerus clusinus Cresson is a synonym of the typical form of *O. pratensis*, which I have now seen from Texas, Oklahoma (Wichita National Forest), New Mexico, Arizona, Utah (Beaver Canyon; Bellevue, Washington Co.) and California (Davis, Solano Co.; Imperial Co.; Owen's Valley, Inyo Co.). The var. *brumalis* J. Bequaert is known from the State of Washington only. The antennal hook of the male of *O. pratensis* differs greatly from that of *O. annectens* and *O. discogaster*, being much shorter, elongate conical and nearly straight. For a further discussion of the species, see J. Bequaert, 1936, Proc. U. S. Nat. Mus., LXXXIV, pp. 86–87.

Odynerus (Rygchium) annectens H. de Saussure

When I described *Odynerus tempiferus* var. *macio*, it seemed remarkable that so striking an insect of the eastern United States should have remained unknown. I have recently come to the conclusion that my var. *macio* is identical with typical *O. annectens* de Saussure. That species, described nearly 80 years ago from a single female, has never since been recorded in print, so far as I know. The type, sent to de Saussure by Edward Norton, is most probably in the author's collection at the Geneva Museum. I have tried to have some of my specimens of *macio* compared with this type, but I have not succeeded thus far.

The structural characters of *O. annectens* were fully described and adequately figured, under *O. tempiferus* var. *macio*, in my paper of 1936. Unfortunately, unauthorized "editing" has resulted in some errors, which are corrected in the sequel.

KEY TO COLOR FORMS OF ODYNERUS ANNECTENS

O. annectens is now known in four color forms, which may be separated as follows:

1. Mostly yellow, with a few ferruginous blotches (especially on mesonotum), practically without black markings.....var. **pritchardi**
   More or less marked with black, at least on mesonotum..... 2
2. Pale markings ivory-white or yellowish-white, restricted on the abdomen to the basal two or three tergites. No pale lateral spots nor ferruginous blotches on second tergite. Wings uniformly and strongly purplish-black.....typical **annectens**
   Pale markings more decidedly yellow or orange, sometimes with ferruginous blotches on some or most of the abdominal segments and on the pronotum. Second tergite sometimes very extensively yellow or orange or with lateral yellow spots connected with the apical fascia. Wings amber-yellow, somewhat infuscate apically..... 3
3. Thorax marked with ferruginous or orange yellow, particularly on pronotum. Larger form, with the second tergite as a rule coarsely punctate or somewhat aciculate before the apex.....var. **tempiferus**
   Thorax mainly black and yellow, not distinctly blotched with orange or ferruginous on the pronotum. Smaller form, with the second tergite usually less roughly punctate before the apex.....var. **eldoradensis**

O. annectens, typical form

Odynerus annectens H. de Saussure, 1870, Rev. Mag. Zool., (2) XXII, p. 59 (♀; "America borealis. Florida?").

Odynerus (*Odynerus*, Div. *Odynerus*) *annectens* H. de Saussure, 1875, Smithson. Miscell. Coll., No. 254, p. 272 (♀; "United States; Florida").

Odynerus tempiferus var. *macio* J. Bequaert, 1936, Proc. U. S. Nat. Mus., LXXXIV, p. 81, fig. 15 A-F (♀♂; mouth of Tobacco Creek, about 25 miles from Fredericksburg, Virginia). A. H. Clark and G. Sandhouse, 1936, *Ibidem*, LXXXIV, p. 89 (nesting habits).

H. de Saussure's brief descriptions agree on the whole with my specimens of *macio*, even though he calls the markings

"yellow" instead of "ivory-white." This may have been due to fading of his specimen; but it should be noted that the ivory-white markings of some other North American wasps (such as *Eumenes fraternus* and *E. globulosus*) were likewise described by de Saussure as "yellow."

The following corrections should be made in my account of *macio* (1936, p. 82): carina margining vertex and cheeks as high on occiput as farther down; median depression of upper half of frons shallow and broad; inter-antennal ridge moderately raised and bluntly rounded off; tegula of normal shape, the outer and inner margins raised, somewhat ridge-like; propodeum without superior ridges, the dorsal areas gradually sloping into the concavity; width of hind margin of first tergite a little over *twice* the median length of tergite; transition between vertical and horizontal areas of first tergite not angular; second tergite seen from above rectangular with slightly convex sides; median basal furrow of second sternite longitudinal; median ridge of concavity of propodeum smooth; tegulae smooth in the middle; narrow ivory-white inner orbits extending to near bottom (*not* base) of ocular sinuses; spots on scutellum either large or small.

Additional Specimens Examined. GEORGIA: One female without more definite locality (U. S. Nat. Mus.); Tifton, one female (F. A. Eddy Collection, now at Mus. Comp. Zool.).

Typical *O. annectens* is now known from Virginia, Georgia and Florida.

O. annectens var. **tempiferus** Viereck

Odynerus (*Stenodynerus*) *tempiferus* Viereck, 1908, Trans. Amer. Ent. Soc., XXXIII, p. 392, Pl. XII, upper right, fig. (♂; Thomas Ranch, Oak Creek Canyon, 20 miles southwest of Flagstaff, Coconino County, Arizona).
Odynerus tempiferus J. Bequaert, 1936, Proc. U. S. Nat. Mus., LXXXIV, p. 80 (♀ ♂).
Odynerus trichiosomus Cameron, 1909, Pomona Jl. Ent., I, p. 127 (♂; Gallinas Canyon, New Mexico).

The following corrections, called for by "editing," should be made to my earlier description of the female of *tempiferus* (1936, p. 80): spots on scutellum and dorsal areas of propodeum either large or small; median black spot of first tergite pentagonal, rectangular or linear; only extreme base of flagellum ferruginous.

Additional Specimens Examined. NEW MEXICO: Santa Fé (T. D. A. Cockerell); Beulah, San Miguel Co. (W. P. Cockerell); Pecos, San Miguel Co. (M. Grabham); Highrolls, Otero Co.; 35 miles east of Santa Fé, 6,000 ft. (H. A. Scullen). COLORADO: Vicinity of Fort Collins (A. B. Klots).

The var. *tempiferus* is now known from New Mexico, Arizona, Colorado, Utah, Wyoming, California and Chihuahua (Mexico). The specimen which I had recorded from Horse Lake, Oregon, was of the var. *eldoradensis*.

O. annectens var. **pritchardi** (new)

Female.—Mostly bright yellow to orange, with a few ferruginous blotches, but without black markings. The following parts are more or less ferruginous: antennae, apical half of mandibles, vertex, outer orbits, lower margin of clypeus, mesonotum, tegulae, extreme base of second tergite (somewhat extended backward medially), and tarsi. The teeth of the mandibles and the upper side of the flagellum are blackish-brown. Wings mostly fuscous with purplish reflections, more amber-yellow at base and along the costa in basal two-thirds. Length (h+th.+t. 1+2): 14 mm.; of fore wing, 15 mm.

Holotype, female, Kenton, Cimarron Co., OKLAHOMA, July 3, 1934 (A. E. Pritchard). Museum of Comparative Zoology, Cambridge, Mass.

O. annectens var. **eldoradensis** Rohwer

Odynerus eldoradensis Rohwer, 1917, Proc. U. S. Nat. Mus., LIII, p. 238 (♂; Tahoe, 6,200 ft., Eldorado Co., California).
Odynerus robustus Rohwer, 1917, Proc. U. S. Nat. Mus., LIII, p. 238 (♀; Tahoe, 6,200 ft., Eldorado Co., California). Not *O. robustus* Provancher, 1895.

The types of both *eldoradensis* and *robustus*, at the U. S. National Museum, were studied by Dr. R. M. Bohart, who first recognized that they are the two sexes of a species by no means rare in California. I have since had the opportunity of examining these types. We have both reached the conclusion that it is not a distinct species, but a form or race of *tempiferus* Viereck.[1] The var. *eldoradensis* averages smaller than the var. *tempiferus*, although some specimens are of the same size. The preapical puncturation of the second tergite is usually much weaker and sparser in *eldoradensis*, but it varies a great deal and seems to offer all transitions to the very rough, aciculate sculpture of *tempiferus*. Some specimens of *eldoradensis* have the lateral angles of the propodeum slightly less prominent than in *tempiferus*, but again all gradations are to be observed. On the whole, the larger specimens of *eldoradensis* differ less from *tempiferus* than the smaller ones.

[1]I am under great obligation to Dr. Bohart for permission to incorporate his conclusions in my paper and to examine specimens which he had compared with Rohwer's types, as well as his other material from California.

The color pattern is fairly variable, as may be seen from the subjoined description. I was at first tempted to separate the specimens without lateral spots on the second tergite as a distinct variety. More extensive material shows this to be impractical. Moreover, Rohwer based his *eldoradensis* on a male lacking the lateral spots of the second tergite, which were well developed in the female type of his *robustus*, both specimens taken in the same locality at the same altitude.

Female.—Black, without ferruginous blotches and with more or less extensive sulphur or ivory-yellow markings as follows: two or four spots on the clypeus, sometimes covering it entirely except for a black anchor-shaped spot; lower inner orbits not quite reaching bottom of ocular sinuses; narrow upper outer orbits; a twin spot between antennae; a triangular spot at base and sometimes a streak near tip of mandibles; a line on under side of scape; a dot or spot on dorsal areas of propodeum (sometimes absent); humeral margin of pronotum; tegulae (except for a median russet spot); a dot or spot on mesopleura beneath base of wing (sometimes absent); sometimes two dots on scutellum; fairly broad apical margins on tergites one to four or one to five, more or less widened on the sides; first and second tergites with or without lateral spots connected with the apical fascia, the spots varying much in size; sometimes a spot on tergite six; apical fasciae on most sternites, often irregular and sometimes reduced to lateral streaks; apices of fore and mid femora and most of the tibiae. Tips of mandibles, inner side and tips of tibiae and all tarsi more or less russet. Wings strongly suffused with amber-yellow and with bright russet veins in basal two-thirds, more grayish and slightly purplish with dark brown veins and stigma in apical third.

Male.—Yellow markings similar to those of the female and as variable. As a rule, the clypeus, under side of scape, outer surface of mandibles, under side of mid and hind coxae, under side of mid femora and base of tarsi are wholly or mostly yellow. Lateral spots are more often present than absent on the first tergite, but more often absent on the second tergite or reduced to minute dots.

Length (h.+th.+t. 1+2): ♀, 11 to 13.5 mm.; ♂, 8.5 to 11.5 mm.; of fore wing, ♀, 10 to 13.5 mm.; ♂, 8.5 to 11 mm.

Specimens Examined. COLORADO: Plainview, Jefferson Co., 7,000 to 8,000 ft. (G. P. Engelhardt); West Cliff, Custer Co.; Colorado Springs (W. F. Wickham); Regnier, 4,500 ft., Baca Co. WYOMING: Camp Roosevelt, Yellowstone Park; Jackson, 6,300 ft., Uinta Co. MONTANA: Helena (W. M. Mann). IDAHO: Warren, Idaho Co. (Miss Elizabeth Becker). NEVADA: Reno. STATE OF WASHINGTON: Snake River, opposite Clarkston, Asotin Co. (A. L. Melander). OREGON: Hood River, Hood River Co. (A. L. Melander); Cornucopia, 6,000 ft., Baker Co.; Rogue River, 7 miles S. of Prospect, 2,175 ft., Jackson Co.

(Bolinger and Jewett); Elgin, Union Co. (A. L. Lovett); Dixie Butt, 7,400 ft., Grant Co. (H. A. Scullen); Wallowa Lake, Aneroid Lake Trail, 5,000 to 6,000 ft., Wallowa Co. (H. A. Scullen); Drakes Peak, 7,800 ft., at flowers of *Eriogonum*, Lake Co. (D. K. Frewing); Elk Lake, Deschutes National Forest, 4,600 ft. (Bolinger and Jewett); Three Sisters, 5,675 ft., Lane and Deschutes Cos. (H. A. Scullen); Horse Lake, High Cascade Mountains, Lane Co. (J. C. Bridwell); Three Mile Ranch, West side Steens Mts., 4,500 ft., Harney Co. (Bolinger and Jewett); Antelope Mt., 6,500 ft., Harney Co. (D. K. Frewing); Anthony-Dutchflat Trail, 7,100 to 7,850 ft., Blue Mts., Baker Co. (H. A. Scullen); Melhorn's Mill near Halfway, Baker Co. (W. J. Chamberlin); Fish Lake, Harney Co. (Stanley Jewett, Jr.). CALIFORNIA: Mt. Hoffman, Tuolumne Co. (G. E. and R. M. Bohart); Mineralking, Tulare Co. (G. E. Bohart); Berkeley (G. E. and R. M. Bohart); Bishop Creek, Inyo Co. (N. W. Frazier); Carrville, 2,400 to 2,500 ft., Trinity Co.; Independence, Inyo Co. (J. W. Johnson); Mammoth, Mono Co.; Briceburg, Mariposa Co. (R. M. Bohart); El Portal, Mariposa Co. (R. M. Bohart); Indian Flat, Mariposa Co. (R. M. Bohart).

The nesting habits of the var. *eldoradensis* are as yet unknown and it will be of great interest to see whether or not they are similar to those of the other forms of *O annectens*.

Odynerus (Rygchium) discogaster, new species

Female.—Head (Fig. 1A) in front view broadly elliptical, slightly wider than high; seen from above, transverse, two and a half times as wide as long; occipital margin slightly curved inward. Vertex and cheeks margined throughout by a sharp carina, which is higher along the cheeks than at the occiput. Cheek above about as wide as upper half of eye in profile, gradually narrowed to mandibular condyle, where it forms a broad groove. Inner orbits at vertex about one and one-fifth times as far apart as at clypeus. Upper half of frons scarcely swollen and not depressed medially. Ocelli in a flattened triangle; posterior pair twice as far apart as from the anterior ocellus, about as far from the eyes as from each other, much farther from the occipital margin. Interocellar area flat, not grooved. Vertex transversely depressed near the occipital margin, the depression bearing two minute foveae, close together. Antennae twice as far apart as from the eyes, the ridge between them low and blunt. Clypeus transversely pear-shaped, about one and one-third times as wide as high, moderately convex with the medio-anterior portion slightly flattened; lower subocular portion much longer than upper interocular part; truncate apex about one-fourth of greatest width of clypeus, slightly but distinctly incurved, with short, bluntly pointed lateral edges. Antennae short, moderately

thick, the flagellum scarcely swollen apically; scape slender, distinctly curved, much less than half the length of the flagellum; third segment about twice as long as fourth; fourth and fifth about as long as wide; sixth to eleventh wider than long; twelfth about as long as basal width. Mandible straight; apex blunt, slightly curved; inner margin with four narrow notches producing broad, bluntly rounded, subequal teeth. Maxillary palpi of 6 subequal, slender segments; labial palpi 4-segmented, the three basal segments gradually shorter, the fourth only one-third of the length of the third. Thorax (Fig. 1B) short and stubby, the sides very slightly converging anteriorly and posteriorly; seen from above little longer than greatest width and in profile about one and one-third times as long as high. Humeral margin of pronotum nearly straight, with a fine carina, briefly interrupted medially; humeri broadly rounded; no ridge between the dorso-lateral and ventro-lateral areas of the pronotum; anterior face of pronotum (between humeral margin and anterior margin) without pits or depressions. Mesonotum about as wide as long, pentagonal in outline, with broadly elliptical anterior margin, very slightly convex, without notauli or parapsidal furrows; anterior half with a fine impressed median line. Tegula semi-elliptical, nearly twice as long as wide, with slightly raised outer margin; post-tegula minute, digitiform. Scutellum rectangular, about three times as wide as long, not raised, flat. Postscutellum convex, with a short, anterior, horizontal area and a much longer, posterior, vertical portion (part of the concavity of the propodeum), the two separated by a transverse, irregularly crenulate crest; no median groove or depression. Median episternal groove very deep, complete; prepectal suture obsolete, indicated in lower part only and not continued toward base of mid coxa. Propodeum very short, squarely and vertically truncate behind, not swollen laterally; dorsal areas far apart medially, gradually sloping into the concavity (no superior ridges), separated from the lateral areas by a slight lateral ridge which raises into an oblique crest at the lateral angles and continues below as a slight inferior ridge; lateral angles not prominent, broadly rounded off; lateral areas slightly depressed; median concavity wide and deep, divided in the upper half by a cordiform area. Abdomen (Fig. 1, B and C) short and very stubby. First tergite short, transverse, as broad as the thorax and scarcely narrower than the second; seen from above broadly semi-elliptical in outline, less than half as long as wide posteriorly; transition between vertical and horizontal areas evenly but strongly convex and rounded off. Second tergite about twice as wide as long, its surface even; apical margins of all tergites and sternites flat, normal. Second sternite gradually sloping basally, a little more convex on the sides, without basal median furrow. Legs normal. Wing with the usual type of venation, as in *O. annectens*.

Head and thorax mostly covered with dense, uniform, medium-sized punctures, somewhat farther apart and more irregular on the cheeks. Mandibles almost impunctate. Disk of clypeus with scattering medium-sized punctures, closer together at the sides where there is a mixture of smaller punctures. Tegulae covered with small punctures. Mesopleura coarsely punctate, almost reticulate; the upper half with transverse striation, continued over the upper half of the metapleura.

Propodeum: dorsal areas coarsely punctate, nearly reticulate; lateral areas with strong, regular, transverse striae and punctures in between; median concavity fairly smooth and shiny, with the merest traces of transverse striae. First tergite without large punctures, but densely covered with an exceedingly small, microscopic punctation; second tergite with a preapical zone of much scattered, medium-sized punctures, extending somewhat along the sides, otherwise covered with the same microscopic puncturation as the first tergite; succeeding tergites and all sternites with a few scattered, medium-sized punctures. Pubescence fairly long and brownish-black on head, thorax and first tergite; much sparser on remainder of abdomen and legs.

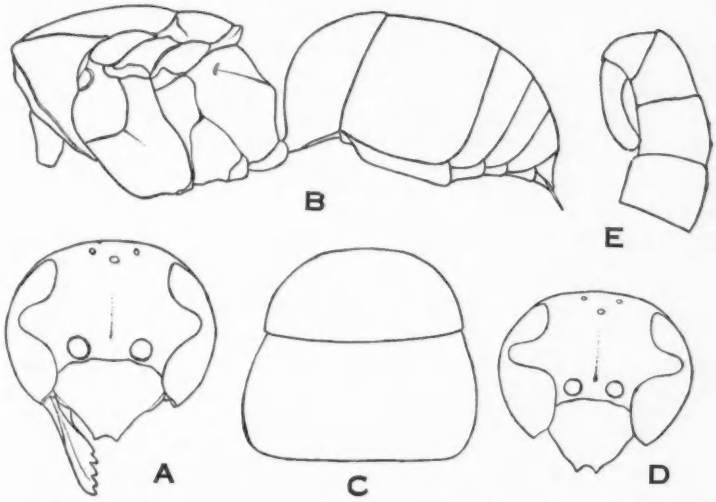

Fig. 1. *Odynerus* (*Rygchium*) *discogaster* J. Bequaert. A, head of female; B, thorax and abdomen of female in profile; C, first and second tergites of female from above; D, head of male; E, tip of antenna of male.

Black, abundantly marked with pale yellow or creamy markings as follows: an elongate spot on base of mandible and sometimes on the disk; clypeus, except for a median wedge-shaped spot; broad inner orbits from clypeus to base of ocular sinus; a large pear-shaped spot between the antennae; a streak at upper outer orbit; a streak on under side of scape; anterior half of dorsal area of pronotum; tegulae, except along inner margin; large spot on upper plate of mesepisternum; two spots on scutellum; transverse ridge of postscutellum; large spots on dorsal areas of propodeum; broad apical bands on tergites 1 to 5, and on sternites 2 and 3 (sometimes also on 4 and 5), the band of the first tergite much widened laterally; a large spot on each side of the disk of the second tergite, sometimes more or less connected laterally with

the apical margin; sometimes a spot on the sixth tergite; broad apices of femora; most of tibiae and basal segment of tarsi; and small spots on mid coxae. Blotches near apices of tibiae, tibial spurs, most of tarsi and claws, russet. Wings subhyaline with a slight yellowish tinge; veins and stigma russet. The black spot of the clypeus varies in shape and size, but I have not seen a female without it. The second sternite is with or without yellow lateral spots, which are sometimes fused with the apical fascia.

Male.—Similar to the female, except as follows: Head (Fig. 1 D) with the clypeus about one and one-fourth times as wide as high, slightly more convex, the lower subocular portion about as long as the upper, interocular part, the truncate apex nearly one-fourth of greatest width, broadly emarginate, with more sharply pointed lateral edges. Vertex without depression or pits. Antennae (Fig. 1 E) slightly longer, segments 4 and 5 longer than wide, 6, 10 and 11 nearly square, 7, 8 and 9 slightly wider than long; thirteenth (or hook) long, slender, finger-shaped with blunt tip (somewhat widened seen from below), not twisted and only moderately curved. Clypeus smooth, with scattered small punctures.

Coloration as in the female, but clypeus entirely, most of outer surface of mandibles and of under side of scape, under side of all coxae and most of femora and tarsi yellow. The lateral spots of second tergite are free or connected with the apical fascia. The spots on scutellum and postscutellum may be present or absent. Sometimes the second sternite is almost wholly yellow.

Length (h.+th.+t. 1+2): ♀, 8.5 to 9.5 mm.; ♂, 6.5 to 8.5 mm.; of fore wing: ♀, 7.5 to 9 mm.; ♂, 6 to 8 mm.

Holotype, female, and *allotype, male,* Mt. Diablo, Contra Costa Co., 1,500 to 2,000 ft., CALIFORNIA, May 12, 1937 (G. E. and R. M. Bohart). Museum of Comparative Zoölogy, Cambridge, Mass. *Paratypes* of both sexes from the same locality in Bohart Collection. *Paratype, female,* Bridger Basin, Uinta Co., WYOMING (S. Garman). *Paratype, male,* Salt Lake City, UTAH (A. L. Lovett).

Described from 11 females and 11 males. I have retained the manuscript name given to this species by Dr. R. M. Bohart.

Odynerus (Rygchium) hidalgo de Saussure

Since my paper dealing with this species (1937, Pan-Pacific Entomologist, XII, pp. 9–14) was published, much additional material has come to hand.

Typical *hidalgo.* IOWA: Dickinson Co. (C. V. Anderson). OKLAHOMA: Wichita National Forest; Stillwater, Payne Co. (C. C. Deonier and E. Hixson); Medford, Grant Co. (H. Lasater); Beaver, Beaver Co. (R. Dahms). According to the label, one of the wasps from Stillwater was bred from a mudcell

built in a *Polistes* nest. TEXAS: Big Bend Park, Brewster Co. (Rollin H. Baker). Mr. Hugo G. Rodeck has informed me that the old Fort Reynolds was located on the south side of the Arkansas River, about 25 miles east of Pueblo, in Pueblo Co., Colorado.

Var. *boreo-orientalis* J. Bequaert. WASHINGTON, D. C. (N. Banks). OHIO: Jug Run, Smithfield, Jefferson Co.; Lawrence Co. (C. H. Kennedy).

Var. *boreo-occidentalis* J. Bequaert. STATE OF WASHINGTON: Leavenworth, Chelan Co. (Wickham). OREGON: fourteen miles east of the Dalles, Wasco Co. (H. A. Scullen); Ten Cent Lake, East side of Steens Mts., near Alberson, Harney Co.; 3 miles south of Elgin, Union Co.; Queen Mine above Cornucopia, 5,000 ft., Baker Co.; Three Mile Ranch, West side of Steens Mts., 4,500 ft., Harney Co. (all Bolinger and Jewett). IDAHO: Lewiston, Ne Perce Co., four stylopized specimens (C. L. Fox). CALIFORNIA: Caribou, Plumas Co. (R. M. Bohart).

HOW TO KNOW THE INSECTS, by H. E. JAQUES. Pages 1–140, 254 figs., 8.5 x 5.5 inches. Planograph. Published by H. E. Jaques, 709 North Main St., Mt. Pleasant, Iowa. Price, spiral binding, $1.00; cloth binding, $1.80.

We have given a notice to this beginners' handy key to the more common families of insects in the ANNALS XXIX: 580, 1936. It first appeared in May, 1936, as a Biological Survey Publication No. 1, Iowa Academy of Science. It had a revision in 1937, and later a third printing in 1937 and now a second revision on the fourth printing. The numerous clear illustrations give it a very positive appeal to the nature lover whose knowledge of the technical key characters of insects is in a state of fog. It is an excellent book for the nature camp where headaches from real study are barred by order of the board of directors.

Our personal experience during twenty summers spent with field classes in beginning entomology is that the sooner the student grinds through the keys to families in "Comstock" or some similar work complete for families north of Mexico, the sooner the student's fear of keys clears up. Right now we need a *thoroughly illustrated* key to North American families of insects. It must be illustrated by a high-class artist who either works with a first-grade taxonomist or is one in his own right. By thoroughly illustrated we mean one which shows characters not only in their highest development but in the various obscure forms critical characters so often assume. This perfection of keys will probably be arrived at through keys by artist specialists on various orders before some general work can be assembled years hence. All published keys help. We are for such books as this by Professor Jaques. They help build the body of amateur entomologists we so sorely need in this country.—C. H. K.

STUDIES ON THE CRANE-FLIES OF MEXICO
PART VI[1]

(Order Diptera, Superfamily Tipuloidea)

CHARLES P. ALEXANDER,
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The species of Tipulidae discussed in this report were all collected by Dr. Alfons M. Dampf, Government Entomologist of Mexico, in the State of Chiapas. The localities and conditions under which the various species were taken have been more fully discussed under the preceding part under this general title (Annals Ent. Soc. America, 31: 393; 1938). I am greatly indebted to Dr. Dampf for the privilege of retaining the types of the novelties described herewith.

Limonia Meigen

Limonia (Geranomyia) civica sp. n.

Mesonotum buffy yellow, the lateral margins darkened, the disk with three narrow brown stripes that are slightly wider than the interspaces; rostrum relatively short, a little more than one-third the length of the body; pleura virtually unmarked; femora with a relatively narrow brown subterminal ring; wings yellow, restrictedly patterned with brown, including a common area at fork of *Sc* and origin of *Rs;* male hypopygium with the rostral spines of the ventral dististyle placed on face of style and very dissimilar in form, both from conspicuous basal tubercles; inner spine reduced to a slender setoid structure; gonapophyses with abundant setulae on their expanded basal portion.

Male.—Length, excluding rostrum, about 8 mm.; wing, 8.5 mm.; rostrum, about 3 mm.

Rostrum black, a trifle longer than the combined head and thorax. Antennae black, relatively long; flagellar segments oval to long-oval, the verticils subequal in length to the segments. Head dark with a pale central median vitta.

Pronotum buffy yellow, with three brown stripes. Mesonotal praescutum buffy yellow, with three narrow brown stripes, additional to the darkened lateral borders behind the yellow humeral region; median dark vitta a little wider than the laterals; interspaces slightly narrower than the stripes; scutal lobes infuscated; median area of scutum and the scutellum pale; postnotum dark brownish plumbeous.

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[1]The preceding part under this general title appeared in these Annals (Vol. XXXI, 393–412, 1938). Contribution from the Entomological Laboratory, Massachusetts State College.

Pleura pale yellow, vaguely darkened on the anepisternum. Halteres with the stem pale, especially at base, the knobs dark brown. Legs with the fore coxae dark brown, remaining coxae and all trochanters yellow; femora obscure brownish yellow, with a relatively narrow brown ring about equal to the clear yellow apex; tibiae brownish yellow, the tips narrowly darkened; tarsi light brown. Wings with a yellow tinge, restrictedly patterned with brown, as follows: A common area at fork of *Sc* and origin of *Rs;* cord and outer end of cell *1st* M_2*;* stigma; supernumerary crossvein in cell *Sc;* very small spots near *h* and at tip of vein R_3*;* a paler cloud at end of vein *2nd A;* veins yellow, slightly darkened in the clouded areas. Venation: *Sc* short, both Sc_1 and Sc_2 ending just beyond the origin of *Rs; Rs* long, arcuated, nearly three times R_{2+3}*;* cell *1st* M_2 shorter than any of the veins beyond it.

Abdominal tergites brown, sternites yellow; hypopygium chiefly pale. Male hypopygium with the tergite narrowly notched medially, the lobes broadly obtuse and with numerous setae. Basistyle very much smaller than the long-oval ventral dististyle; rostral prolongation of the latter long and slender, the usual spines placed on face of style below the base of the prolongation; spines very dissimilar in form, the outer stout and straight, from a basal tubercle that is subequal in length and merges gradually into the spine; inner spine reduced to a slender seta that is nearly as long as its much stouter basal tubercle. Dorsal dististyle a short, stout, strongly curved hook. Gonapophyses with the expanded basal portion densely provided with short setulae; mesal apical lobe darkened, narrowed gradually to the acute black tip. Anal tube with few coarse setae.

Holotype, ♂, Vergel, Chiapas, altitude 800 meters, above a waterfall in a damp valley, at light, June 1, 1935 (A. M. Dampf); M. F. 4384.

The most similar species are *Limonia* (*Geranomyia*) *erygramma* Alexander (Mexico-Panama) and *L.* (*G.*) *recondita* Alexander (Peru), both of which differ in the wing-pattern, color of thorax and structure of the male hypopygium. The femora of the above-mentioned species are uniformly darkened, not annulate as in the present fly.

Limonia (Geranomyia) uberis sp. n.

Size very large (wing, ♂, 10 mm.); mesonotal praescutum brownish yellow with three narrow brownish black stripes; femora obscure yellow, with a broad dark brown subterminal ring; wings with the ground color light yellow, very heavily patterned with brown, the cells beyond the cord almost uniformly darkened; a common dark area at origin of *Rs* and fork of *Sc;* Sc_1 ending shortly before midlength of *Rs;* male hypopygium with the ventral dististyle large, with a single well-developed spine from a long curved base, the second spine rudimentary; anal tube densely hairy.

Male.—Length, excluding rostrum, about 9 mm.; wing, 10 mm.; rostrum, about 4 mm.

Rostrum black. Antennae black throughout. Head dark blackish gray, with a narrow median gray line on vertex.

Pronotum black. Mesonotal praescutum obscure brownish yellow, with three narrow brownish black stripes, the median one ending before the suture; scutal lobes extensively brownish black; scutellum obscure brownish yellow; postnotum brownish yellow, darker behind. Pleura weakly infuscated, the sternopleurite paler. Halteres yellow. Legs with the coxae yellow, the fore coxae more darkened basally; trochanters yellow; femora obscure yellow, with a broad (0.8 mm.) dark brown subterminal ring, preceded by a subequal clearer yellow ring, the apex narrowly (about 0.2 mm.) of the latter color; tibiae brownish yellow, the tips narrowly darker; tarsi obscure yellow, the outer segments blackened. Wings with the ground color light yellow, chiefly concealed by an unusually extensive brown pattern; cells beyond cord almost uniformly darkened, variegated by small ground areas in cells R_2, *1st* M_2 and M_3; before the cord, the yellow ground is more extensive, subequal in area to the dark, more evident near the wing-base and just before the cord; a large common dark area involves both the origin of *Rs* and fork of *Sc*, enclosing a small central pale spot; dark band at level of the supernumerary crossvein in cell *Sc*, considerably widened behind in cells *M*, *Cu* and *1st A*, the last-named cell dark except at base; veins dark, yellow in the ground areas. Venation: *Sc* relatively long, Sc_1 ending shortly before midlength of *Rs*, Sc_2 at its tip; cell *1st* M_2 longer than any of the veins beyond it.

Abdominal tergites brown, the sternites somewhat paler, yellowish brown; hypopygium chiefly pale yellow. Male hypopygium with the basistyle much smaller than the ventral dististyle, the ventro-mesal lobe dusky, extensive. Ventral dististyle with the rostral prolongation short and stout, with a single well-developed spine, this arising from a long curved swollen base that is about two-thirds as long as the spine itself; a second rudimentary spine is present, so small as to be scarcely evident, subequal in length to the smaller setae near it, arising from a small swollen base, the apex of the spine truncated. Gonapophyses with mesal-apical lobe terminating in an unusually slender, pale, curved point. Anal tube densely covered by dense black hairs, additional to the usual coarse setae.

Holotype, ♂, Vergel, Chiapas, altitude 800 meters, at light, 10 P. M. to 6 A. M., May 13, 1935 (A. M. Dampf); M. F. 4153.

Limonia (*Geranomyia*) *uberis* is so distinct from all other described species of the subgenus that comparison with other forms is unnecessary. The combination of large size, unusually heavy wing pattern, and the structure of the male hypopygium furnish strong specific characters.

Limonia (Geranomyia) trichomera sp. n.

General coloration of mesonotum reddish brown, the praescutum with four narrow silvery lines, the intermediate ones on either side of a slightly wider brownish black median vitta; femora with a narrow

brown subterminal ring; wings subhyaline, sparsely patterned with darker, including a series of four small costal areas; *Sc* long; male hypopygium with the gonapophyses blackened, their surface with abundant short erect setulae.

Male.—Length, excluding rostrum, about 6.5 mm.; wing, 7 mm.; rostrum, about 3 mm.

Rostrum black, nearly one-half the length of body; maxillary palpi unusually long. Antennae black throughout; flagellar segments suboval, with truncated ends. Head black, the narrow anterior vertex silvery, less distinctly prolonged backward onto the posterior vertex; posterior orbits narrowly gray.

Pronotum reddish brown, darker laterally. Mesonotal praescutum reddish brown, with four narrow silvery lines, the intermediate pair on either side of a slightly wider brownish black median vitta, the lateral stripes about mid-distance to the lateral margin; scutum and scutellum reddish brown, with a continuous median silvery line; postnotal mediotergite reddish brown. Pleura pale brown dorsally, paling to yellow beneath. Halteres with stem pale, knob dusky. Legs with coxae and trochanters yellow; femora yellow, with a narrow brown subterminal ring, the slightly more extensive tip yellow; tibiae and tarsi brown; claws with a group of three or four teeth close to base. Wings subhyaline, sparsely patterned with darker, including a series of four small costal areas, the largest stigmal; second area at origin of *Rs*, third at fork of *Sc*, the latter two widely separated; very narrow to scarcely evident seams along cord and outer end of cell *1st* M_2; veins pale, darker in the clouded areas. Venation: *Sc* long, Sc_1 ending shortly beyond midlength of *Rs*, Sc_2 at its tip; R_2 a little shorter than R_{1+2}; cell *1st* M_2 subequal to vein M_{1+2} beyond it; *m-cu* close to fork of *M*.

Abdomen dark brown, the hypopygium very slightly paler. Male hypopygium with the ventro-mesal lobe of basistyle relatively long, simple. Ventral dististyle large and fleshy, much more extensive than the basistyle; rostral prolongation short but relatively stout, shorter than the two rostral spines, these latter arising from a small pale tubercle close to base of prolongation; each spine nearly twice as long as the prolongation itself. Gonapophyses with mesal-apical lobe blackened, high and erect, the surface with abundant short erect setulae, the tip further produced into a long, gently curved spine.

Holotype, ♂, Finca Belem, Chiapas, altitude 850 meters, June 23, 1935 (A. M. Dampf); M. F. 4610.

Limonia (*Geranomyia*) *trichomera* is entirely distinct from other described species of the subgenus in Tropical America. Elsewhere in this fauna, the setuliferous gonaphyses are found only in *L.* (*G.*) *umbricolor* Alexander, of Brazil.

Limonia (Rhipidia) sejugata sp. n.

Allied to *multifida;* antennae (male) with ten bipectinate flagellar segments, the branches short; thorax dark brown, the pleura and a conspicuous pale triangular area on side of praescutum yellow; wings

yellow, restrictedly patterned with small brown spots; abdominal tergites bicolored; male hypopygium with the ventral dististyle small; rostral prolongation slender, with a single strong curved spine before midlength.

Male.—Length about 5.5 mm.; wing, 6 mm.

Rostrum and palpi black. Antennae with scape, pedicel, terminal segment and all flagellar branches black, the pedicels of the flagellar segments white; flagellar segments one to ten, inclusive, bipectinate, the longest branches about one-half longer than the segments; terminal segment exceeding the penultimate in length. Head dark gray; anterior vertex very narrow.

Pronotum dark brown. Mesonotal praescutum dark brown in front and again on posterior third, the central portion paler, the entire lateral region of the sclerite occupied by a major yellow pollinose area that also involves almost all the pleura, contrasting conspicuously with the dark color; posterior sclerites of notum dark brown, the median area of scutum narrowly pale. Pleura as described, yellow, the propleura, ventral sternopleurite and pleurotergite dark brown. Halteres yellow. Legs with the fore coxae and trochanters light yellow; remaining coxae and trochanters conspicuously dark brown; remainder of legs light yellow, the terminal tarsal segments blackened. Wings with the ground color yellow, restrictedly patterned with small brown spots, as follows: Origin of *Rs;* tip of *Sc;* outer end of the otherwise chiefly pale stigma; cord and outer end of cell *1st* M_2; small marginal spots at ends of veins R_3 to *2nd A*, inclusive, slightly larger on the last-named vein, smallest on R_{4+5}; proximal end of usual stigmal area with a weak dark cloud, the central portion pale, as described; veins pale, darker in the clouded areas. Venation: Sc_1 ending opposite or just beyond midlength of *Rs;* cell *1st* M_2 longer than vein M_4 beyond it; *m-cu* at or shortly before fork of *M*.

Abdominal tergites bicolored, brownish yellow, the caudal borders of the segments narrowly dark brown; sternites more uniformly yellow, the subterminal segments darkened; hypopygium pale. Male hypopygium with the tergite rather deeply emarginate, each lobe terminating in four or five fasciculate setae, the margins with numerous normal setae. Basistyle with the setae of ventro-mesal lobe of normal length; face of style near base of lobe with a group of erect setae. Dorsal dististyle a very strong, curved, slender hook, at apex narrowed into a long straight point. Ventral dististyle unusually small, subequal in area to the basistyle; rostral prolongation long and slender, before midlength with a single strong curved spine.

Holotype, ♂, Finca Victoria, Chiapas, altitude 900 meters, June 29, 1935 (A. M. Dampf); M. F. 4710. *Paratopotypes*, 2 ♂♂; *paratype*, ♂, Vergel, altitude 800 meters, June 10, 1935; M. F. 4503.

Most nearly related to *Limonia* (*Rhipidia*) *multifida* Alexander (Mexico), differing in the coloration, the short flagellar branches, and in the details of structure of the male hypopygium,

especially the more shallowly emarginate tergite, with fewer, more flattened setae on lobes, the different structure of the lobe of basistyle, and the small ventral dististyle, with strongly curved rostral spine.

Limonia (Rhipidia) hirtilobata sp. n.

General coloration of mesonotum dark brown, the pleura and broad lateral praescutal triangles yellow; antennae (male) with nine bipectinate segments, the branches of moderate length; fore coxae pale, middle and posterior coxae black; wings with a strong brownish tinge, with a greatly reduced darker pattern; *m-cu* at or shortly beyond the fork of *M;* male hypopygium large and complex in structure; tergite and lobes of basistyles with unusual development of setae; rostral spines two, unequal in length and thickness.

Male.—Length about 5–5.2 mm.; wing, 5.5–5.8 mm.; antenna about 2 mm.

Rostrum and palpi black. Antennae relatively short, as shown by the measurements; basal three segments dark, flagellar segments with basal enlargements and branches black, apical pedicels pale, terminal segment uniformly darkened; flagellar segments two to ten, inclusive, bipectinate, the first and eleventh merely short-produced; terminal segment simple; longest branches short, approximately twice the segments. Head dark brownish gray; eyes contiguous or nearly so.

Pronotum infuscated. Mesonotal praescutum with the sides extensively yellow, sparsely pruinose, the median area chiefly covered by a central brown stripe that is most intense in front and behind, slightly more reddish at midlength; posterior portion of praescutum and posterior sclerites of notum almost uniformly dark brown. Pleura with propleura and metapleura darkened, the extensive mesopleura pale yellow, confluent with the pale sides of praescutum. Halteres with stem pale, knob infuscated. Legs with the fore coxae pale, middle and posterior coxae black; trochanters obscure yellow; remainder of legs broken. Wings with a strong brownish tinge, with a greatly reduced darker pattern, including very small, inconspicuous areas at origin of *Rs*, fork of *Sc*, cord and outer end of cell *1st* M_2; stigma bicolored, the proximal portion pale, scarcely differentiated from the ground, the outer end darkened at R_2; veins pale brown. Venation: *Sc* relatively short, Sc_1 ending opposite or just beyond one-third the length of *Rs*, Sc_2 at its tip; cell *1st* M_2 closed, subequal in length to vein M_3 beyond it; *m-cu* at or shortly beyond the fork of *M*.

Abdominal tergites dark brown, the caudal borders of the segments narrowly more brownish black; sternites and hypopygium yellow. Male hypopygium unusually large and very complex in structure. Tergite shallowly notched medially, each lobe obliquely truncated; caudal margin of lobes with modified setae, including a more mesal group of about eight long flattened setae, and an outer fasciculate group that becomes twisted at near one-third their length. Basistyle with the ventro-mesal lobe conspicuous, at apex with a group of very long pale setae, on mesal face of basistyle just caudad of the lobe with a low blackened flange. Ventral dististyle moderately large, the rostral

prolongation stout at base, at near midlength narrowed and flattened; two unequal rostral spines at near one-third the length of the prolongation, the more basal a short straight spine from a low base, the second spine placed at base of the first, more slender and more than one-half longer. Gonapophyses with mesal-apical lobe slender, the tip slightly recurved and narrowly blackened.

Holotype, ♂, Finca Victoria, Chiapas, altitude 900 meters, June 29, 1935 (A. M. Dampf); M. F. 4710. Paratopotypes, 2 ♂♂, June 28–29, 1935; M. F. 4693, 4710.

Limonia (*Rhipidia*) *hirtilobata* is one of the most distinct species of the subgenus so far made known, the structure of the male hypopygium being quite unique among the described forms. In coloration, the fly comes closest to the otherwise amply distinct *L.* (*R.*) *sejugata* sp. n.

Shannonomyia Alexander

Shannonomyia dampfi sp. n.

General coloration gray, the praescutum with three brown stripes; antennae (male) elongate, nearly as long as the body; flagellar segments cylindrical, with long coarse outspreading setae; head clear light gray, the broad anterior vertex silvery; legs brownish yellow, the outer tarsal segments darkened; wings with a brownish tinge; macrotrichia of cells very reduced in number; cell *1st* M_2 closed; male hypopygium with the gonapophyses massive, blackened, each with from three to five coarse spines.

Male.—Length about 6 mm.; wing, 6 mm.; antenna about 5 mm.

Rostrum pruinose; palpi black. Antennae (male) very elongate, as shown by the measurements; scape and pedicel pale yellow, flagellum black; flagellar segments cylindrical, with long coarse erect setae distributed throughout the length of the segment, the longest about two-thirds the length of the segments; terminal segment about one-third the length of the penultimate, with setae at apex. Head clear light gray, more silvery on the front and wide anterior vertex.

Pronotum pale, sparsely pruinose, darkened laterally. Mesonotal praescutum gray, with three brown stripes; scutum dark brown; scutellum and a basal triangle on mediotergite gray, the posterior lateral angles of latter darkened. Pleura and pleurotergite dark brown dorsally, the sternopleurite and meron paler. Halteres dusky, the base of stem very restrictedly paler. Legs with the fore coxae weakly darkened, the remaining coxae and all trochanters yellow; remainder of legs brownish yellow, the outer tarsal segments darkened. Wings with a brownish tinge, the small stigma a trifle darker; prearcular and costal regions a little darker than remainder of ground; veins brown. About three macrotrichia in extreme outer end of cell R_4. Venation: Sc_1 ending a short distance before the fork of Rs, Sc_2 a short distance before tip; Rs relatively long, nearly three times R_{2+3+4}; R_2 faint, subequal to R_{2+3}; R_{1+2} a little shorter than R_{2+3+4}; veins R_3 and R_4

divergent, so cell R_3 at margin is very wide; cell M_1 lacking; *m-cu* variable in position, even in a single specimen, on the left wing of type being about two-thirds its length beyond the fork of *M*, on right wing close to fork.

Abdomen dark brown, the discal portions of the more basal segments a little brighter; hypopygium obscure yellow. Male hypopygium with the outer dististyle pale, darkened at apex, bidentate, the outer spine longer and more slender than the inner. Inner dististyle pale, broad-based, the apex slender. Gonapophyses appearing as massive blackened structures, each with about three to five coarse spines. Aedeagus elongate, pale.

Holotype, ♂, Finca Germania, Chiapas, altitude 1190 meters, June 20, 1935 (A. M. Dampf); M. F. 4571. *Paratype*, ♂, Finca Victoria, altitude 900 meters, June 29, 1935; M. F. 4710B.

Shannonomyia dampfi is named in honor of the collector, Dr. Alfons M. Dampf, to whom our greatest knowledge of the insects of Mexico is due. The species is so distinct that it requires no comparison with others so far described. The only other species with elongate antennae is *S. myersiana* Alexander (Jamaica) which has abundant macrotrichia in all outer cells of wing, cell *1st* M_2 open by the atrophy of *m*, and the hypopygium, especially the gonapophyses and aedeagus, quite differently constructed. The relations of these various aberrant species that have been referred to *Shannonomyia* remain in question, due to lack of material.

Hexatoma Latreille

Hexatoma (Eriocera) substolida sp. n.

Allied to *macrocera;* general coloration of notum brown, sparsely pruinose on posterior sclerites; praescutal interspaces with pale sparse setae; antennae (male) elongate, exceeding three times the length of body, flagellum black; halteres dark brown, the extreme base of stem pale; femora pale brown, the tips scarcely darker; wings with a weak brown tinge, including the costal region; *Rs* strongly arcuated to nearly square at origin; abdominal tergites almost uniformly brown, the incisures not darker, the lateral borders of the outer segments more yellowish.

Male.—Length about 6.5 mm.; wing, 8 mm.; antenna about 23 mm.

Rostrum greatly reduced, obscure yellow; palpi brown. Antennae with scape and pedicel obscure yellow, flagellum black; flagellum (male) greatly elongated, as in the *macrocera* group; spines of flagellar segments relatively few and scattered, the row on basal segment including seven or eight spines. Head pale brown, sparsely pruinose; vertical tubercle large and bulbous, entire.

Mesonotum chiefly brown, sparsely pruinose, especially behind; praescutum with three barely indicated darker stripes; vestiture of

praescutal interspaces pale and erect. Pleura dark brown. Halteres dark brown, the extreme base of stem restrictedly pale. Legs with the coxae brownish yellow; trochanters yellow; femora pale brown, the tips scarcely darker; tibiae and tarsi dark brown. Wings with a weak brown tinge, the costal and subcostal cells not brightened, as in *stolida*; stigma oval, darker brown; cord and vein R_5 darker brown than the other veins. Venation: *Rs* moderately long, strongly arcuated to nearly square at origin, slightly shorter than in *stolida*.

Abdominal tergites almost uniformly brown, the incisures not darkened, on outer segments the lateral borders of the segments slightly more yellow; basal sternites brownish yellow with the incisures darkened; subterminal sternites uniformly brown; hypopygium dark.

Holotype, ♂, Finca Belem, Chiapas, altitude 800 meters, June 22, 1935 (A. M. Dampf); M. F. 4602.

The present fly is very closely allied to the larger *Hexatoma* (*Eriocera*) *stolida* Alexander, of northern Panama, agreeing in most details of coloration and venation, yet presenting some characters that make it impossible to consider the two flies as being identical. The chief differences lie in the color of the halteres, legs and wings, the lack of darkened incisures on the abdominal tergites, and in slight venational characters.

Hexatoma (Eriocera) aurantionota sp. n.

Mesonotum orange, unmarked; pleura pale brown; head with vertical tubercle and adjoining portions of posterior vertex fiery orange, the posterior portions of head darkened; legs chiefly brownish black; wings with a weak brown suffusion, the costal border darker brown; abdomen with basal five tergites yellow, the caudal margins dark brown, the outer segments more uniformly blackened.

Female.—Length about 16 mm.; wing, 10.5 mm.

Rostrum brown; palpi black. Antennae 10-segmented; basal three segments yellow, succeeding segments dark brown; terminal three flagellar segments subequal. Head with vertical tubercle and that portion of posterior vertex behind it fiery orange; sides of posterior vertex and genae broadly grayish brown; vertical tubercle relatively high, notched medially.

Pronotum brown. Mesonotum uniformly orange, without markings, parascutella a little darker. Pleura pale brown, the surface weakly pruinose; a brown spot on membrane before wing-root. Halteres black, the base of stem restrictedly pale. Legs with coxae brownish yellow, pruinose; trochanters yellow; remainder of legs brownish black, the proximal ends of femora, tibiae and basitarsi slightly paler. Wings with a weak brown suffusion, the prearcular region and cells *C* and *Sc* darker brown; stigmal region vaguely darkened; veins along cord a little suffused; veins brown. Longitudinal veins beyond cord without trichia, excepting a scattered series along R_5. Venation: *Sc* long, Sc_1 ending shortly beyond *r-m; Rs* one-half longer

than R_{2+3+4}; R_2 about twice R_{2+3} and subequal to R_{1+2}; cell *1st* M_2 shorter than vein M_{1+2} beyond it; *m-cu* at fork of *M*.

Abdomen with basal five tergites yellow, the caudal margins of segments two to five dark brown, the amount increasing on the outer segments; terminal segments almost uniformly darkened, the seventh tergite obscure yellow in center; sternites yellow, the subterminal segments weakly darkened; ovipositor with the genital shield and moderately elongate cerci black.

Holotype, ♀, Huixtla, Chiapas, altitude 30 meters, November 21, 1930 (A. M. Dampf); M. F. 1944.

Hexatoma (*Eriocera*) *aurantionota* is closest to *H.* (*E.*) *obsoleta* (Williston), of Honduras, differing in the small size and in many details of coloration, as the antennae, legs and wings.

Hexatoma (Eriocera) subgracilis sp. n.

General coloration brown to brownish black; basal segments of antennae yellow; head fiery orange, vertical tubercle entire; femora and tibiae yellow, the tips narrowly blackened; wings with a strong brownish tinge, the prearcular and costal border darker brown; trichia of veins beyond cord reduced in number; Sc_2 stronger than Sc_1; R_2 immediately before fork of R_{2+3+4}; *m-cu* beyond fork of *M*; abdomen black, the basal portions of tergites three and four very slightly paler; hypopygium fiery orange.

Male.—Length about 11 mm.; wing, 9 mm.

Rostrum yellow; first segment of palpus obscure yellow, outer segments dark brown. Antennae (male) 7-segmented; scape, pedicel and basal half of first flagellar segment yellow, succeeding segments passing into brownish black; terminal flagellar segments elongate, a little longer than the penultimate. Head entirely fiery orange; vertical tubercle moderately high, entire.

Pronotum brown, pruinose. Mesonotal praescutum with the ground color brown, with four, dull brownish black stripes that are narrowly bordered by darker; posterior sclerites of notum brownish black, mediotergite more pruinose, especially adjoining the sunken areas at anterolateral angles. Pleura brownish black, sparsely pruinose. Halteres black, base of stem restrictedly obscure yellow. Legs with coxae dark brown; trochanters brownish yellow; femora yellow, the tips narrowly blackened, the amount involving about the distal eighth or less and nearly equal on all legs; tibiae yellow, the tips narrowly dark brown; basitarsi brownish yellow, the tips and remainder of tarsi brownish black. Wings with a strong brownish tinge, the prearcular and costal regions darker brown; stigmal area not indicated; veins brown. No macrotrichia on veins beyond cord excepting a very sparse series the entire length of the distal section of vein R_5. Venation: *Sc* moderately long, Sc_1 weak, erect, ending shortly before level of *r-m*, Sc_2 much stronger, subequal; R_{2+3+4} about two-thirds *Rs*; R_2 subequal to R_{1+2}, placed just before fork of R_{2+3+4} so a very short to punctiform R_{3+4} is left; cell *1st* M_2 shorter than vein M_{1+2} beyond it; *m-cu* nearly one-third its length beyond the fork of *M*.

Abdomen black, the basal portions of tergites three and four very slightly paler; hypopygium and preceding segment fiery orange.

Holotype, ♂, Huixtla, Chiapas, altitude 30 meters, November 21, 1930 (A. M. Dampf); M. F. 1944.

The nearest ally of the present fly appears to be *Hexatoma* (*Eriocera*) *gracilis* (Osten Sacken), from Orizaba, Mexico, which differs in the large size and in details of coloration, especially the thorax and legs.

Atarba Osten Sacken

Atarba (Atarba) scutata sp. n.

General coloration yellow, the sides of the praescutum and the scutal lobes intensely blackened; antennae weakly bicolored, black, the extreme proximal ends of the more basal segments pale; legs yellow, the tips of the femora conspicuously blackened; wings brownish yellow, stigma medium brown; *Sc* short; *Rs* and basal section of R_5 subequal and in oblique alignment; abdominal tergites bicolored; male hypopygium with apical point of outer dististyle slender; aedeagus weakly expanded at tip.

Male.—Length, 4.5–5 mm.; wing, 5–5.5 mm.; antenna about 2.2–3 mm.

Female.—Length, 6.5 mm.; wing, 6 mm.

Rostrum yellow; basal segment of palpus yellow, the remainder black. Antennae (male) moderately long; scape and pedicel yellow; flagellum weakly bicolored, black, the extreme proximal ends of the more basal segments yellow; beyond the third or fourth segments uniformly blackened; flagellar segments long-cylindrical, the verticils shorter than the segments. Head brownish yellow, the sides of the posterior vertex darkened; setae of vertex long and conspicuous, dark.

Thorax pale yellow, conspicuously variegated with black on the posterior lateral portions of the praescutum and on the scutal lobes, the median area remaining of the ground color; dorsal anepisternum weakly darkened. Halteres with stem pale yellow, knob darkened. Legs with the coxae and trochanters yellow; femora yellow, the tips abruptly blackened; remainder of legs yellow, the outer tarsal segments weakly darkened. Wings with a brownish yellow tinge; stigma medium brown; veins brownish yellow. Venation: *Sc* short, Sc_1 ending opposite or just before the origin of *Rs; Rs* and basal section of R_5 short, nearly straight and in oblique alignment; *m-cu* variable in position, from close to fork of *M* to near midlength of the cell.

Abdominal tergites bicolored, the bases of the segments yellow, the apical half brownish black; in male with a black subterminal ring; hypopygium yellow. Male hypopygium with the apical point of the outer dististyle long and slender, gently decurved at tip; subapical spine appressed, nearly as long as the apex; two larger spines and two smaller denticles on outer margin, these progressively larger outwardly. Aedeagus large, weakly expanded at tip. Appendage of ninth sternite with caudal margin subtransverse to very shallowly notched; lateral horns short.

Holotype, ♂, Finca Victoria, Chiapas, altitude 900 meters, June 29, 1935, 11 P. M. to morning (A. M. Dampf); M. F. 4710B. *Allotype*, ♀, Vergel, altitude 800 meters, July 2, 1935; M. F. 4744. Paratypes, with the allotype, ♂, May 23, 1935, M. F. 4268; 1 ♀, June 3, 1935; M. F. 4416.

The nearest relative of the present fly would seem to be *Atarba* (*Atarba*) *tatei* Alexander, of Ecuador, which has the aedeagus similarly constructed and agrees in other characters. The pattern of the mesonotum and structure of the outer dististyle of the male hypopygium readily separate the present fly from other regional species having the aedeagus simple.

Elephantomyia Osten Sacken

Elephantomyia (Elephantomyia) luteiannulata sp. n.

General coloration polished ferruginous yellow; rostrum long, dark brown; femora yellow basally, at near one-third the length passing into brown, the tips blackened, preceded by a clear yellow ring of subequal width; tibiae brown, tarsi black; wings gray, stigma long-oval, dark brown; wings petiolate basally, cell *2nd A* very narrow, reduced to a linear strip; abdomen yellow, the segments narrowly ringed caudally with black; subterminal segment and genital shield black.

Female.—Length, excluding rostrum, about 8.5 mm.; wing, 7.5 mm.; rostrum about 6.5 mm.

Rostrum about three-fourths the length of the body, dark brown. Antennae with scape pale brown, remainder of antennae brownish black. Head brownish yellow, paler yellow behind; anterior vertex of female subequal in width to diameter of scape.

Mesonotum uniform ferruginous yellow, polished, the pleura clearer yellow. Halteres dark brown, the extreme base of stem pale. Legs with coxae and trochanters yellow; femora yellow basally, at near one-third the length passing into brown, the tips blackened, preceded by a clear yellow ring of subequal width; tibiae brown to dark brown; tarsi black; tibiae without true spurs but with a powerful fasciculate bristle before tip. Wings petiolate basally, gray, the prearcular and basal costal fields slightly more yellowish; stigma long-oval, dark brown, conspicuous; veins dark brown. Venation: *Sc* moderately long, Sc_1 ending shortly before fork of *Rs*, Sc_2 close to its tip; branches of *Rs* only slightly divergent; cell R_2 at margin wider than cell R_3; cell *1st* M_2 long-rectangular, exceeding vein M_4 beyond it, *m-cu* at near one-third the length of the cell; cell *2nd A* very narrow, reduced to a linear strip.

Abdomen yellow, the segments narrowly ringed caudally with black; subterminal segment and genital shield black; valves of ovipositor horn-yellow, elongate.

Holotype, ♀, Finca Victoria, Chiapas, altitude 900 meters, June 29, 1935 (A. M. Dampf); M. F. 4710A.

Elephantomyia (*Elephantomyia*) *luteiannulata* is very distinct from the other described species of the genus, being especially characterized by the pattern of the femora and the unusually narrow cell *2nd A* of the wings.

Teucholabis Osten Sacken

Teucholabis (Teucholabis) patens sp. n.

General coloration of mesonotum dark brown; head polished black; pleura brown, with a broad black dorso-longitudinal stripe; halteres black throughout; femora obscure brownish yellow, the tips rather narrowly blackened; wings grayish subhyaline, the apical quarter deepening into pale brown; cell *1st* M_2 open by the atrophy of the basal section of M_3; abdomen black; male hypopygium with the outer dististyle relatively slender, at near midlength with a nearly erect slender spine.

Male.—Length about 6 mm.; wing, 5.8 mm.

Rostrum black, approximately as long as remainder of head; palpi black. Antennae black throughout; flagellar segments oval. Head polished black, the post-genae paler.

Cervical sclerites black. Pronotum obscure brownish yellow. Mesonotum dark brown to slightly piceous, the lateral portions of praescutum and the scutal lobes slightly more intense. Pleura brown, the entire dorsal mesopleura occupied by a broad black longitudinal stripe; surface of pleura not or scarcely white pruinose, as in many species of the genus. Halteres black throughout. Legs with the fore coxae brownish black, remaining coxae and all trochanters brownish yellow; femora obscure brownish yellow, the tips rather narrowly but conspicuously blackened; tibiae yellowish brown, the tips passing into black; tarsi black; posterior basitarsi weakly dilated. Wings grayish subhyaline, the prearcular and basal portions more whitish, the apical quarter deepening to pale brown; stigma short-oval, dark brown; veins brownish black, those in basal fifth paler. Venation: *Sc* relatively long, Sc_1 ending about opposite midlength of *Rs*, Sc_2 a short distance from its tip; *Rs* long and unusually straight; R_2 subequal to R_{2+3+4}; branches of *Rs* nearly parallel to one another for almost their whole length; cell *1st* M_2 open by atrophy of basal section of M_3, cell *2nd* M_2 about one-half longer than its petiole; *m-cu* about two-thirds its length beyond fork of *M*.

Abdomen, including hypopygium, black. Male hypopygium with the spine of basistyle small and slender, the tip acute, the surface with numerous setae; flange of mesal face of basistyle blackened and irregularly roughened but not forming a single definite plate. Outer dististyle relatively slender, at near midlength bearing a nearly erect slender spine; more basally, on mesal face, with two or three stout retrorse tubercles or spines; apex of style terminating in an acute point. Aedeagus relatively slender, terminating in a strong black spine and with a shorter nearly apical lobe that bears four strong setae, the spine and lobe separated from one another by a narrow U-shaped notch.

Holotype, ♂, Vergel, Chiapas, altitude 800 meters, May 23, 1935 (A. M. Dampf); M. F. 4268.

Teucholabis (*Teucholabis*) *patens* is entirely distinct from the other species having cell *1st* M_2 open, these including *T.* (*T.*) *gowdeyi* Alexander, *T.* (*T.*) *liponeura* Alexander, *T.* (*T.*) *lipophleps* Alexander, *T.* (*T.*) *nigroterminalis* Alexander, *T.* (*T.*) *omissa* Alexander and *T.* (*T.*) *omissinervis* Alexander. It is most generally similar to *T.* (*T.*) *furva* Alexander, which has cell *1st M* closed and with a very distinct hypopygium.

Teucholabis (Teucholabis) perangusta sp. n.

Allied to *oteroi;* general coloration yellow and black, the lateral praescutal stripes reaching the outer margins; basal portion of knob of halteres darkened; femoral rings very narrow; wing pattern very pale brown; stigma small, subcircular; *Sc* long, Sc_1 extending to about opposite two-thirds the length of *Rs;* abdominal sternites lined on either side with dark brown; male hypopygium with spine of basistyle relatively short and stout, terminating in a short black lateral spine.

Male.—Length about 9 mm.; wing, 7 mm.

Female.—Length about 9 mm.; wing, 6.5 mm.

Rostrum dark brown; palpi brownish black. Antennae with scape yellow, pedicel yellowish brown, flagellum black; flagellar segments oval, the verticils slightly exceeding the segments. Head yellow, the anterior vertex at narrowest point and a spot on center of posterior vertex dark brown.

Pronotum chiefly obscure yellow, variegated with darker. Mesonotal praescutum yellow, with three black stripes, the median one not reaching the suture behind, at posterior end nearly confluent with the laterals which likewise do not reach the suture but are deflected laterad to the margin; scutum yellow, the lobes extensively blackened; scutellum brownish yellow, parascutella darker; mediotergite yellow, the posterior third darkened. Pleura chiefly pale, the surface with a white bloom; anepisternum and pleurotergite extensively darkened. Halteres yellow, the basal portion of knob extensively infuscated. Legs with the coxae and trochanters yellow; femora yellow, the tips narrowly dark brown, the amount subequal on all legs; at or just before midlength of femora with a very narrow pale brown ring; tibiae yellow; tarsi yellow, the terminal tarsal segments darkened; posterior basitarsi (male) slightly enlarged and darkened, with an elongate sensory area; claws simple. Wings relatively wide (male), whitish subhyaline, restrictedly banded with pale brown; stigma subcircular, dark brown; band at cord more extensive than others, virtually complete; basal band restricted, extending from vein *M* to just beyond *2nd A;* wing tip narrowly but conspicuously darkened; veins yellow, darker in the clouded areas. Venation: *Sc* long, Sc_1 extending to nearly opposite two-thirds *Rs*, Sc_2 a short distance from its tip; cell *1st* M_2 closed.

Abdominal tergites yellow; sternites with a conspicuous linear black streak on either side; hypopygium yellow. Male hypopygium with the spine of basistyle relatively short and broad, the apex subtruncate,

with one side produced into a short black spine; marginal flange of basistyle with relatively few coarse blackened teeth, the more cephalic ones larger. Outer dististyle relatively slender, dusky, with conspicuous setae almost to base, not terminating in a single acute spine. Inner dististyle without a slender apical lobe, as in *oteroi*. Aedeagus with setae abundant and conspicuous, exceeding a score in number; outer lateral angle not produced into a lobe, as in *oteroi*.

The female is generally similar to the male but darker, the scutellum and pleura chiefly black, and with the abdominal tergites ringed with black.

Holotype, ♂, Santa Isabel, Chiapas, altitude 800 meters, November 16, 1930 (A. M. Dampf); M. F. 1879. *Allotype*, ♀, Vergel, altitude 800 meters, May 25, 1935 (A. M. Dampf); M. F. 4288.

The nearest relative of the present fly is undoubtedly *Teucholabis* (*Teucholabis*) *oteroi* Alexander (Cuba), which, while generally similar in the coloration of the body and legs, differs conspicuously in the structure of the male hypopygium.

Gonomyia Meigen

Gonomyia (Lipophleps) subinermis sp. n.

Belongs to the *manca* group; pleural stripes lacking; male hypopygium with the dististyle fleshy, relatively small; phallosome with two blackened points, the longest slender-stemmed, moderately dilated before the apical point.

Male.—Length about 2.5–2.7 mm.; wing, 2.8–3.1 mm.

Rostrum testaceous yellow; palpi brownish black. Antennae black. Head dark brown.

Pronotum and lateral pretergites yellow. Mesonotal praescutum brown, the humeral region obscure yellow; scutum brown, the median area a trifle paler; scutellum yellow, the base more darkened medially; postnotum testaceous brown. Pleura brownish testaceous, paler behind, without evident stripes. Halteres darkened. Legs with the coxae yellowish testaceous, the fore pair somewhat darker; trochanters brownish yellowish; remainder of legs dark brown. Wings broad, strongly tinged with brownish gray; stigma pale brown, very faintly indicated; veins brown. Venation: *Sc* short, Sc_1 ending a distance before origin of *Rs* about equal to from one-half to two-thirds the length of the latter; branches of *Rs* strongly divergent; *m-cu* at fork of *M*.

Abdominal tergites brown, sternites paler; hypopygium yellow. Male hypopygium with the dististyle single, fleshy, smaller than in *inermis*. Phallosome with two blackened points, as in *inermis*, but these quite distinct in conformation; longest arm with a very slender stem, before apex moderately expanded, thence produced into a slender black apical spine; second point very nearly equal in length and size to the first, longer than in *inermis*, arising from a moderately expanded pale basal plate, provided with marginal setae.

Holotype, ♂, Escuintla, Chiapas, altitude 80 meters, November 11, 1930 (A. M. Dampf); M. F. 1814. Paratopotype, ♂.

Gonomyia (*Lipophleps*) *subinermis* is most closely related to *G.* (*L.*) *inermis* Alexander (British Guiana), differing most evidently in the hypopygial structure, as described above.

Gonomyia (Lipophleps) orthomeroides sp. n.

Belongs to the *manca* group; allied to *orthomera;* thoracic pleura testaceous yellow, pruinose, without clearly defined stripes; male hypopygium with the basistyle produced directly into a slender straight spine, the tip narrowly blackened; a single very small, fleshy dististyle; phallosome consisting of a long slender aedeagus arising from a flattened basal plate that is further produced into a single blade with the tip microscopically toothed.

Male.—Length about 2.8–3 mm.; wing, 3–3.2 mm.

Female.—Length about 4 mm.; wing, 3.5 mm.

Rostrum testaceous yellow; palpi brownish black. Antennae brownish black; verticils very long, especially in male. Head brown.

Mesonotum testaceous brown, the lateral pretergites restrictedly yellow; scutellum a little brightened. Pleura testaceous yellow, pruinose, without clearly evident stripes. Halteres pale, the knobs weakly darkened, dull yellow when rubbed. Legs with the coxae pale; trochanters testaceous; remainder of legs brown. Wings uniformly suffused with brown, the prearcular and costal regions a little paler; veins pale brown. Venation: *Sc* relatively short, Sc_1 ending a distance before origin of *Rs* about equal to from one-half to two-thirds the length of the latter; branches of *Rs* strongly divergent; extreme tip of R_{1+2} atrophied; *m-cu* at or a short distance before the fork of *M*.

Abdominal tergites brown, sternites paler; hypopygium yellow. Male hypopygium with the basistyle narrowed outwardly and very gradually produced into a slender straight spine that is tipped with black, the darker portion set off by a weak constriction; at base of spine a single, unusually small, fleshy dististyle, bearing two long powerful fasciculate setae. Phallosome consisting of a long slender aedeagus, arising from a flattened basal plate; at base of aedeagus, the plate is produced into a single blade, its tip microscopically toothed.

Holotype, ♂, Huixtla, Chiapas, altitude 30 meters, November 21, 1930 (A. M. Dampf); M. F. 1944. *Allotopotype*, ♀. *Paratopotypes*, ♂ ♂; *paratypes*, ♂, Escuintla, Chiapas, altitude 80 meters, November 11, 1930; M. F. 1814; ♂, El Zapote, Chiapas, altitude 450 meters, November 15, 1930; M. F. 1867. *Gonomyia* (*Lipophleps*) *orthomeroides* is closest to *G.* (*L.*) *orthomera* Alexander (Puerto Rico), differing very conspicuously in the details of structure of the male hypopygium, especially the nature of the spine of the basistyle, the unusually small fleshy dististyle, and the very slender aedeagus.

Erioptera Meigen

Erioptera (Empeda) divaricata sp. n.

General coloration pale reddish brown, the praescutum without clearly defined stripes; legs yellowish brown, the terminal tarsal segments darker; femora with elongate flattened scales, in addition to normal setae; wings with a slight brown tinge, stigma scarcely differentiated; Sc_1 ending nearly opposite one-third *Rs;* male hypopygium with the outer dististyle a nearly straight pale rod, at near midlength bearing a long slender erect arm that is strongly curved on outer portion.

Male.—Length about 2.5 mm.; wing, 2.8–3 mm.

Female.—Length about 3 mm.; wing, 3.3–3.5 mm.

Rostrum ochreous; palpi dark brown. Antennae dark brown. Head brown.

Mesothorax almost uniformly pale reddish brown, without clearly defined praescutal stripes; pseudosutural foveae pale; pretergites more yellow; pleura more testaceous. Halteres pale, the knobs weakly darkened. Legs with the coxae and trochanters pale yellow; remainder of legs yellowish brown, the terminal tarsal segments darker; legs with elongate flattened scales, in addition to the setae. Wings with a slight brown tinge, cells *C* and *Sc*, with the prearcular field, more yellowish; stigma scarcely differentiated; veins brown. Venation: Sc_1 ending nearly opposite one-third the length of *Rs;* R_2 a little shorter than R_{2+3+4}; veins R_3 and R_4 moderately divergent, cell R_2 at margin a little less than cell R_3; cell M_2 open; *m-cu* at fork of *M*.

Abdomen pale brown; hypopygium large, more reddish brown. Male hypopygium with the outer dististyle a nearly straight pale rod, the tip obtuse to obliquely truncated, at near midlength bearing a long slender erect arm that is only a little shorter than the apex of style beyond it, its tip strongly curved. Inner dististyle a little shorter than the outer and of nearly the same conformation but unbranched.

Holotype, ♂, Vergel, altitude 1000 meters, June 3, 1935 (A. M. Dampf); M. F. 4415. *Allotopotype*, ♀, with male. *Paratopotypes*, several hundreds, altitude 800–1200 meters, May 11–July 2, 1935; M. F. 4123, 4124, 4132, 4151, 4152, 4156, 4172, 4185, 4191, 4192, 4193, 4196, 4203, 4205, 4206, 4207, 4210, 4223, 4239, 4245, 4259, 4260, 4267, 4268, 4277, 4288, 4320, 4321, 4333, 4334, 4350, 4351, 4353, 4367, 4384, 4386, 4398, 4399, 4415, 4416, 4417, 4418, 4430, 4502, 4503, 4524, 4525, 4633, 4641, 4659, 4743, 4744; *paratypes*, ♂ ♂, Finca Aurora, June 18, 1935, M. F. 4552; Finca Belem, June 23, 1935, M. F. 4615; Finca Germania, June 20, 1935, M. F. 4571; Finca Lubeca, June 21, 1935, M. F. 4582, 4583; Finca San Cristobal, June 19, 1935, M. F. 4560; Finca Victoria, May 29–June 29, 1935, M. F. 4342, 4693, 4693B, 4694, 4709, 4710A and 4710B.

Erioptera (*Empeda*) *divaricata* is readily distinguished by the structure of the male hypopygium, especially by the erect elongate arm of the outer dististyle.

Erioptera (Empeda) deludens sp. n.

General coloration dark brown, the pleura more testaceous brown; wings with a faint brown tinge, the stigma scarcely differentiated; Sc_1 ending about opposite one-third the length of Rs; R_{2+3+4} shorter than R_{3+4}; male hypopygium with the outer dististyle uniformly blackened, profoundly bifid, the outer arm a long simple blade, the shorter inner arm expanded and irregularly lobed at apex; inner dististyle a pale simple rod, slightly narrowed on distal half, the apex obtusely truncated.

Male.—Length about 2.5–2.6 mm.; wing, 3–3.2 mm.

Rostrum brownish yellow; palpi dark brown. Antennae dark brown, the basal flagellar segments paler. Head gray.

Mesonotum almost uniformly dark brown, the anterior lateral pretergites restrictedly pale. Pleura testaceous brown. Halteres brown, the base of stem restrictedly yellow. Legs with the coxae and trochanters testaceous; remainder of legs brown, the outer segments dark brown; legs with elongate scales in addition to the normal setae. Wings with a faint brown tinge, the stigma scarcely differentiated; prearcular and costal regions a little more yellowish; veins pale brown. Venation: *Sc* moderately long, ending about opposite one-third the length of Rs; R_{2+3+4} shorter than R_{3+4}; R_3 relatively long, longitudinal in position, lying generally parallel to R_4; cell M_2 open; *m-cu* at fork of *M*.

Abdominal tergites dark brown, sternites more brownish yellow; hypopygium pale brown. Male hypopygium with the outer dististyle uniformly blackened, profoundly bifid, the outer arm a long simple blade that gradually narrows to the subacute apex; inner arm shorter, with a short stout stem, at apex expanded into a very irregularly bilobed or multilobed head. Inner dististyle subequal in length to the inner arm of outer style, pale, appearing as a simple rod, nearly parallel-sided or slightly narrowed on distal half, the apex obtusely truncated.

Holotype, ♂, Vergel, Chiapas, altitude 1200 meters, June 3, 1935 (A. M. Dampf); M. F. 4415. *Paratopotypes*, ♂ ♂, altitude 800–1200 meters, May 13–June 3, 1935; M. F. 4153, 4192, 4415.

Erioptera (*Empeda*) *deludens* is entirely distinct from other regional species in the structure of the male hypopygium, especially the outer dististyle.

Molophilus Curtis

Molophilus (Molophilus) subsagax sp. n.

Belongs to the *plagiatus* group; general coloration of mesonotum pale brown; antennae (male) relatively long, about equal in length to the combined head and thorax; male hypopygium with the basal

dististyle a long, gently sinuous rod that terminates in an acute spine; at near two-thirds the length on outer face with a small appressed spine; surface of style with conspicuous minute spines and spinulae.

Male.—Length about 3.5 mm.; wing, 4 mm.; antenna about 1.4 mm.

Rostrum and palpi black. Antennae black throughout, moderately long, about equal in length to the combined head and thorax; flagellar segments oval to long-oval, with very long conspicuous verticils. Head dark brown.

Mesonotum almost uniformly pale brown, the praescutal interspaces a trifle darker. Pleura dark brown. Halteres infuscated. Legs with the coxae brownish testaceous; trochanters obscure yellow; remainder of legs dark brown to brownish black; tibiae and tarsi black. Wings relatively wide, tinged with brown; veins and macrotrichia darker brown. Venation: R_2 lying some distance beyond the level of *r-m;* petiole of cell M_3 a little more than twice the oblique, sinuous *m-cu;* vein *2nd A* long, sinuous, ending about opposite midlength the petiole of cell M_3.

Abdomen, including hypopygium, dark brown. Male hypopygium with the apical beak of basistyle slender, curved. Basal dististyle a long, gently sinuous rod, terminating in an acute spine; at near two-thirds the length on outer face with a small appressed spine; surface of style with conspicuous minute spines and spinulae, including several on basal half; just before tip, the style bears microscopic setae so arranged as to produce a striate appearance. Phallosomic plate narrow, glabrous, the distal end oval.

Holotype, ♂, Finca San Cristobal, Chiapas, altitude 1090 meters, June 19, 1935 (A. M. Dampf); M. F. 4560.

Molophilus (*Molophilus*) *subsagax* is closest to *M.* (*M.*) *sagax* Alexander, which differs especially in the short male antennae and in the details of structure of the male hypopygium, especially the armature of the basal dististyle.

Molophilus (Molophilus) retrorsus sp. n.

Belongs to the *gracilis* group and subgroup; general coloration dull black; antennae short; wings strongly blackened; male hypopygium with the ventral lobe of basistyle produced laterad into a long straight spine; outer dististyle a flattened curved blade, the outer margin with a series of retrorse spines; phallosomic plate microscopically setulose.

Male.—Length about 3.5 mm.; wing, 4.2 mm.

Rostrum and palpi black. Antennae short, if bent backward extending about to wing-root, black throughout; flagellar segments oval. Head dark gray, the anterior vertex and narrow orbits lighter gray.

Anterior lateral pretergites restrictedly obscure yellow. Mesonotum dull black, the median region of scutum, scutellum and postnotum very slightly more pruinose. Pleura black, sparsely pruinose. Halteres blackened, the knobs slightly brightened. Legs with the fore coxae black, the remaining coxae and all trochanters obscure yellow; remainder

of legs black, the bases of the fore femora restrictedly pale. Wings strongly blackened, the veins vaguely seamed with still darker; veins coarse, dark brown; macrotrichia dark. Venation: R_2 lying a short distance beyond the level of *r-m; m-cu* about one-half the petiole of cell M_3; vein *2nd A* relatively short, ending some distance before the level of *m-cu*.

Abdomen, including the hypopygium, black. Male hypopygium with the ventral lobe of basistyle at apex produced laterad into an acute straight spine; dorsal lobe longer, obtusely rounded at tip. Outer dististyle a broadly flattened sickle-shaped blade, the tip subacute; outer margin on distal half with a series of retrorse spines; inner margin at near midlength with a series of erect denticles of various sizes. Inner style nearly as long, curved, slender, the outer margin on distal third with microscopic spinules, these becoming larger and more conspicuous just before apex. Phallosomic structure oval, the surface microscopically setulose.

Holotype, ♂, Vergel, Chiapas, altitude 800 meters, June 12, 1935 (A. M. Dampf); M. F. 4525.

Molophilus (*Molophilus*) *retrorsus* is entirely different from other members of the genus so far described. It is the first species of the *gracilis* group to be discovered in Middle America.

Cryptolabis Osten Sacken

Cryptolabis (Cryptolabis) longiradialis sp. n.

General coloration dark brown, the anterior lateral pretergites conspicuously light yellow; femora and tibiae yellow, the tips narrowly and gradually infuscated; wings with a uniform pale brown tinge; macrotrichia in all cells beyond cord; *Rs* unusually long, on basal half approximated to R_1; male hypopygium with two dististyles or lobes of a single style, the outer a flattened pale lobe, the inner one complex.

Male.—Length about 3.5–4 mm.; wing, 3.5–4 mm.

Female.—Length about 4 mm.; wing, 4.2 mm.

Rostrum and palpi brown. Antennae short, brown throughout. Head dark.

Pronotum dark. Anterior lateral pretergites conspicuously pale yellow, becoming more obscure behind. Mesonotum almost uniformly dark brown, the scutal lobes more polished brownish black. Pleura brown, more blackened dorsally; pleural membranes pale. Halteres with stem brown, paler basally, knob pale yellow. Legs with coxae and trochanters pale; femora and tibiae yellow, the tips narrowly and gradually infuscated; tarsi brown. Wings with a uniform pale brown tinge, the extreme base pale yellow; veins brown. Macrotrichia of cells abundant, including all cells beyond cord except in their basal portions; a few scattered trichia proximad of cord, in outer ends of cells *R*, *Cu* and *1st A*, and, in cases, cell R_1; in cell *R* these punctures follow a line or fold that is a direct prolongation of the base of cell M_2, paralleling vein *M*. Venation: *Sc* moderately long, ending about opposite four-fifths to five-sixths the length of the unusually long *Rs*,

the latter approximating R_1 on basal half, thence diverging; R_{2+3+4} subperpendicular at origin, a little longer than R_{2+3}; *m-cu* opposite or before midlength of M_{3+4}.

Abdomen dark brown throughout. Male hypopygium with two dististyles or lobes of a single style. Outer style a long pale lobe, provided with abundant short setae. Inner style subequal in length but more complex, narrowed at base, gently expanded outwardly, the outer angle produced into a curved black spine; just inside this blackened point, a dark flattened plate or flange; near outer mesal angle of style a group of three stout spinous setae; surface of style near apex with several very long, slender setae. Aedeagus stout, long and straight.

Holotype, ♂, Vergel, Chiapas, altitude 800 meters, May 11, 1935 (A. M. Dampf); M. F. 4123. *Allotopotype*, ♀. *Paratopotype*, ♂; a second ♂, May 30, 1935; M. F. 4350.

Cryptolabis (*Cryptolabis*) *longiradialis* is readily told from the other regional species by the elongate *Rs*, in conjunction with the coloration of the body and wings. All other Mexican species have *Rs* short and oblique. The male hypopygium of the present fly is very different from that of all other described species.

CATALOGUE OF PUBLICATIONS, DR. W. JUNK, 4 to, 130 pages, 1939. Van Bleiswijkstraat 87, Den Haag, Holland.

In this notice we are deviating from our usual rule of ignoring items which might be considered advertising. This elegant volume on rag stock covers the publications which have originated in the publishing firm of "Dr. W. Junk."

In June, 1935, the second-hand book department was sold. At present the firm has for sale only its own publications. Junk's fame rests largely on his Catalogus Coleopterorum of 31 large volumes, but that is only an item in his extensive business of the publication of basic biological literature. Another encyclopaedic catalogue is his Fossilium Catalogus of many volumes. Of interest to entomologists are his catalogues in many volumes on Lepidoptera, on Orthoptera, on Hymenoptera. He publishes such journals as "Mycopathologia" and "Enzymologia." Facsimile editions of famous works no longer obtainable at any just price are another specialty. He lists fifteen such published. One to be published is a two-volume edition of the famous work on coleopterous larvae by Schiödte, "De Metamorphosi Eleutheratorum Observationes," 900 pp., 86 pls. (more than 1200 figures). We notice, Bodenheimer, "Materialen zur Geschichte der Entomologie bis Linne," 1928–1929, 1,000 pages, 28 plates, 255 text figs.

It is these larger works which take faith and courage on the part of the publisher and, above all, a comprehensive knowledge of biology plus a similar broad knowledge of the intricacies of the publishing business. Junk was bright enough to move his business out of Germany about one year ahead of the time when he probably would have lost it to the Nazi.—C. H. K.

NEW ANTS OF RARE GENERA AND A NEW GENUS OF PONERINE ANTS

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From collections of ants made by myself in the West Indies and Northern South America, incidental to studies on the biology of fungus-growing ants (Attini),[1] the following remarkable new cerapachyines and ponerines are selected for description.[2]

All types, except that of *Thaumatomyrmex manni*, are in the author's collection. *T. manni* is in the U. S. National Museum.

The members of the Cerapachyinae constitute a separate subfamily linking the Dorylinae with the Ponerinae and in addition merit special attention because of their rarity and distribution.

The finding of two species of two subgenera of *Cerapachys* adds the continent of South America to the distribution of this widespread but discontinuously distributed genus. Of this genus the late Dr. W. M. Wheeler (1922, p. 53) remarked: "It seems hardly possible that species of *Cerapachys, sensu latiore*, are entirely lacking in South America, but none has been found in any of the many extensive collections that have been made on that continent."

Though these ants were taken in Trinidad, this island is only seven miles from the mainland of Venezuela and is South American (Guianan) in all respects rather than West Indian (Lesser Antillean).

Since no specimens of *Cerapachys, sensu strictu*, had been found in the New World, the occurrence of a species in Trinidad is of especial note since it reasonably may be considered endemic. It was found in low forest away from cultivations near the famous Pitch Lake in the southwestern part of the island. The few other species are found in Africa, Madagascar, India, and New Guinea.

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[1]Most of these studies were undertaken while holding a National Research Fellowship in Biology at the Imperial College of Tropical Agriculture, Trinidad, B. W. I.

[2]Drawings made by Miss Helen Wilson.

The one record of *Cerapachys* (*Syscia*) in the New World is of *Syscia seini* described from Puerto Rico in 1931 by Dr. W. M. Mann,[3] who considered it and *S. silvestrii* of Hawaii probably endemic to New Guinea and introduced into these islands. The few other species are recorded from Australia, India, and New Guinea.

The finding of a new species of this subgenus in Trinidad would seem to indicate that perhaps both this subgenus and *C.* (*Cerapachys*) may be endemic to the New World. They both may be archaic relicts of a formerly world-wide genus.

The two species would seem to have none of the behavior characteristics which enable such introduced ants as *Pheidole megacephala, Monomorium pharaonis, Tapinoma melanocephalum* and *Paratrechina longicornis* to establish themselves over the warmer parts of the world and even drive out much of the native ant fauna. One of the species was found upon three occasions in two years, but only in a very small area and intensive collecting in many other nearby parts of the island never revealed it.

Three of the rarest genera in the primitive subfamily of ants, the Ponerinae, are the genera *Acanthoponera, Thaumatomyrmex,* and *Discothyrea,* each known from but a few specimens of a very few species. All are striking and easily distinguished from other ants. Ants of the genus *Acanthoponera* possess an antennal fossa prolonged backwards over the eyes, epinotal spines or dentations, and usually a petiole terminating in a spine. Ants of the genus *Thaumatomyrmex* are characterized by their narrow, arcuate mandibles with long, spiniform teeth. All of the ants of the genus *Discothyrea* are very small, the worker being only a millimeter or two in length, with the number of its antennal joints reduced to nine or even less, and with the terminal joint comparatively large and ovate.

Aside from their rarity and unusual appearance these ants merit special attention because of their distribution.

Of the ten described species of *Acanthoponera,* including the species here described, seven are found in the Neotropical Region, two in Australia, and one in New Zealand. The neotropical distribution is chiefly in the southern part of South

[3]The late Dr. W. M. Wheeler (1937, p. 441) overlooked this record when he stated: "This remarkable genus (*Cylindromyrmex*) and the subfamily Cerapachyinae to which it belongs were not previously known to have representatives in the Antilles."

America, in southern Brazil and in Chile, Bolivia, and the Argentine. One variety is recorded from Costa Rica and Mexico, one subspecies from Guatemala, one variety from Panama, and the species here described is from Trinidad. The two subgenera, *Anacanthoponera* and *Acanthoponera* (s. str.) are both found in this region, but only *Anacanthoponera* is recorded from Australia and New Zealand.

Thaumatomyrmex is distinctly a neotropical genus and the three previously recorded species, each known from but two or a very few specimens, are found in Cuba, Honduras, and southern Brazil. The species here described from British Guiana and Trinidad is thus toward the middle of the range.

Discothyrea, like *Acanthoponera*, is found in New Zealand and the Neotropical Region but several species are found in the East Indies, one in Kamerun, and the genotype is supposed to be from "North America," although in the original description no locality is mentioned.

The new genus, *Wadeura*, from the Arawak Indian name for small ponerine ants, is mostly closely related to *Pseudoponera* whose typical subgenus is Indomalayan and whose subgenus *Promyopias* is Ethiopian. Two species in this new genus are here described, one from Panama, the other from the far interior of British Guiana. The *Pseudoponera-Wadeura* group of species include a series ranging from *P. amblyops* (genotype) with long and narrow mandibles bearing seven distinct teeth and very small eyes, through *Wadeura* with mandibular armature reduced to two large and one small teeth and without eyes, to *Promyopias* with nearly edentate mandibles and eyes obsolete or absent.

Cerapachys

Cerapachys (Cerapachys) neotropicus, sp. nov.

(Fig. 1)

Worker.—Length, 3 mm. Head, excluding mandibles, slightly over 1⅓ as long as wide, rectangular with gently convex sides and transverse occipital margin; anterior clypeal margin gently convex with minute medial tooth; mandibles trigonal with finely and irregularly denticulate cutting margin; frontal carinae in form of close, slightly divergent anteriorly, subvertical lamellae; antennal fossa sub-circular, bounded laterally by distinct carinae; eyes closer to mandibles than to occiput, very small, only slightly convex. Antennae 12-jointed; scapes clavate, all funicular joints transverse except terminal joint. Thorax from

above twice as long as wide; rectangular with slightly convex pronotal margin, slightly impressed laterally in meso-epinotal region and from here posteriorly slightly convex at sides; epinotum convex between the distinct teeth. Petiole from above 1¼ longer than wide, quadrangular with posterior corners rounded, posterior margin and sides feebly convex. Postpetiole from above slightly longer than petiole and nearly 1½ times broader, trapezoidal with feebly and irregularly convex sides. Gaster distinctly constricted between first and second segments, the latter distinctly larger than the former. Legs moderately short.

Body shining, with coarse but only moderately abundant setigerous punctations. Legs smooth and shining with very few punctations.

Hairs fine, yellowish white, upright or inclined, limited to punctations on body, more numerous on appendages. Antennal funiculi with sparse, short hairs interspersed with short, appressed pubescence.

Color dark reddish brown, appendages lighter brown.

Described from one worker taken by myself among leaves in low forest near Guapo Bay, Gulf of Paria, Trinidad, B. W. I., April 4, 1935. This locality is near the famous Pitch Lake and the area has an annual rainfall of between 70 and 80 inches. The forest was characterized by the abundance of the cocorite palm (*Maximiliana caribaea*).

Cerapachys (Syscia) ierensis, sp. nov.

Worker.—Length, 2.1–2.2 mm. Head, excluding mandibles, one-seventh longer than broad, rectangular with feebly convex sides rounding into evenly concave occipital margin and feebly convex anterior clypeal margin. Mandibles trigonal with acute apical tooth and finely denticulate cutting margin. Frontal lamina projecting as acute, feebly divergent teeth. Antennal scrobes bordered laterally by strong carinae. Eyes lacking. Antennae 9-jointed; scape strongly clavate, extending slightly more than half-ways to occipital margin; funicular joints 2–7 distinctly broader than long, terminal joint long-elliptical, longer than preceding three joints taken together. Thorax from above sub-rectangular, slightly over twice as long as broad, with convex pronotal margin and sides slightly impressed at meso-epinotal suture; in profile evenly and slightly convex. Epinotal declivity plane, feebly carinate on sides. Petiole from above trapezoidal with feebly convex sides converging anteriorly and convex posterior margin; in profile with rounded dorsum, higher anteriorly, and large ventral lobe produced anteriorly. Postpetiole from above trapezoidal with feebly convex sides converging anteriorly, a little longer than petiole and one-fourth wider; in profile with basal half produced anteriorly as a large lobe and with feebly convex dorsum.

Gaster from above ovate, 1st gastric segment comprising about nine-tenths of gaster. Legs short, with thickened femora and tibiae; basal tibial joint of prothoracic leg equal in length to distal four taken together.

Sub-lucid; with dense and moderately coarse setigerous punctations.

Moderately pilose, with fine reclinate to recumbent yellowish white hairs interspersed with much longer, sparser, and more upright hairs.

Color uniformly yellowish brown.

Described from a series of workers taken in small tunnels in red clay in the same banana plot at St. Augustine, Trinidad, B. W. I., but in two different years, May 17, 1935, and May 20, 1936. The first year I found them in small tunnels just above the fungus gardens of a nest of *Acromyrmex octospinosus* Reich between four mature banana stalks. The ants were at first thought to be dorylines because they beat their antennae upon the ground before them as they crawled along in single file, precisely as do the army ants. This observation further substantiates the removal of this group of ants from the ponerines to a separate subfamily, the Cerapachyinae. They were not strongly negatively phototropic but "felt" their way cautiously in their tenuous tunnels. One worker was carrying beneath it with ease a larva, fully two-thirds its own length, whose long axis was parallel to that of the ant. When the two were put in alcohol the worker maintained its grip for many seconds. Another larva was resting in an L-shaped position but was soon carried off. A single worker was taken nearby August 3, 1935, among leaves at the base of a saman tree (*Pithecolobium saman*). When the banana plot was revisited in 1936 workers were found at the base of a mature banana clump in small tunnels from near the surface to a depth of at least 12 cm. Brood was found, not in a single brood chamber, but in small pockets off from the tunnels and of only slightly larger dimensions. Their doryline behaviour was again noted.

This species differs from cotypes of *Syscia silvestrii* Wheeler of Hawaii in the Museum of Comparative Zoology in slightly smaller size, shorter antennal scapes, more rounded postpetiole, seen from above, and in paler color. Judging from the description and drawing of *Syscia seini* Mann of Puerto Rico, *ierensis* differs in slightly larger size, longer head and antennal scapes, less impressed sides of thorax, proportionately broader and more convex postpetiole, seen from above, and in other ways. The three species are evidently closely related.

The poetic Indian name for Trinidad is Iere, land of the humming bird.

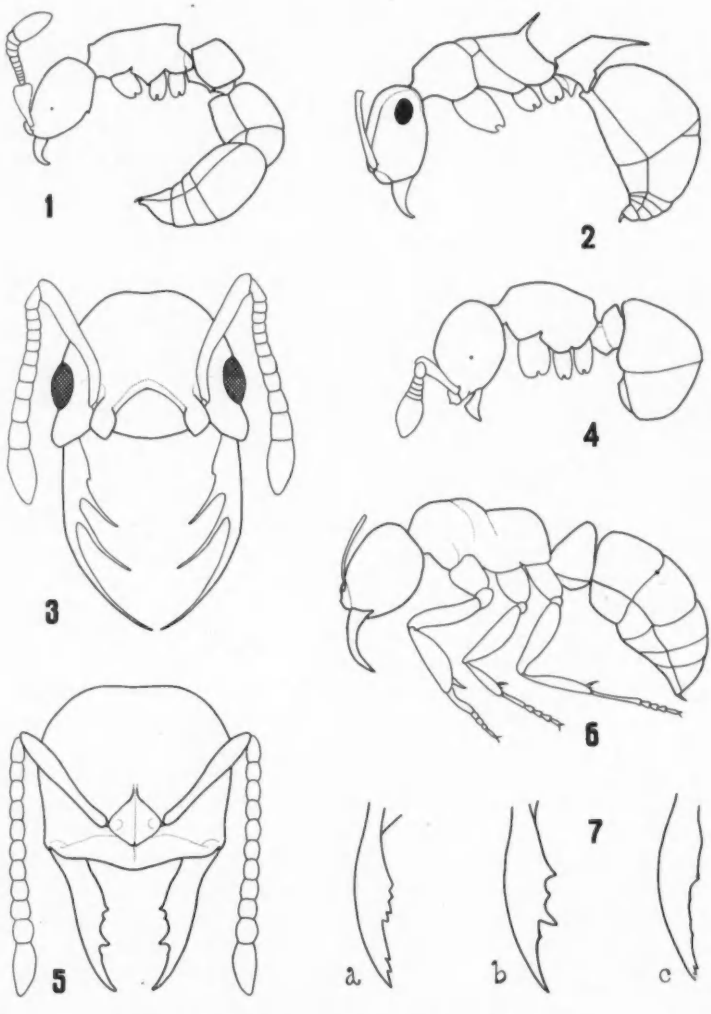

Fig. 1. *Cerapachys* (*Cerapachys*) *neotropicus*, sp. nov. Worker.
Fig. 2. *Acanthoponera* (*Acanthoponera*) *spininodis*, sp. nov. Worker.
Fig. 3. *Thaumatomyrmex atrox*, sp. nov. Worker.
Fig. 4. *Discothyrea denticulata*, sp. nov. Worker.
Fig. 5. *Wadeura guianensis*, gen. et sp. nov. Worker.
Fig. 6. *Wadeura guianensis*, gen et sp. nov. Worker.
Fig. 7. Mandibles of (a) *Pseudoponera amblyops*, (b) *Wadeura haskinsi*, sp. nov. and (c) *Promyopias silvestrii*. (a and c after Emery.)

Acanthoponera

Acanthoponera (A.) spininodis, sp. nov.
(Fig. 2)

Worker.—Length, 4.2–4.3 mm. Head, excluding mandibles, barely longer than broad in front of eyes. Anterior clypeal margin straight, sides of head in front of eyes convex, occipital angles nearly rectangular, occipital margin slightly concave. Eyes large, convex. Frontal carinae lamellate in front of eyes, gradually decreasing posteriorly into vermiculate rugae. Antennal scrobes extending around posterior corners of head to back of eyes. Antennal scapes not quite extending to occipital margin. Mandibles triangular; with 6–8 irregular teeth. Pronotum from above convex, slightly more than twice as broad as basal surface of epinotum in front of spines, anteromedially produced as low, laterally compressed, truncate tubercle. Thorax in profile slightly impressed at pro-mesonotal and meso-epinotal sutures. Epinotal spines from above diverging, slightly longer than the width of the basal surface in front of them, in profile straight, directed backwards and upwards. Petiole with spine distinctly longer than epinotal spines and forming dorsally an obtuse angle, ventrally a concavity. Gaster ovate. Legs of moderate length.

Sculpturing of head, thorax and petiole coarsely reticulate-rugose; median carina extends length of head over clypeus to occipital margin; proximal two-thirds of petiolar spine sculptured as on petiole. Gaster smooth but for fine setigerous punctations. With moderately abundant fine, upright hairs of moderate length interspersed with more abundant short hairs which on the gaster become a reclinate, silky pubescence.

Color uniformly yellowish-brown.

Described from two workers taken by myself on the summit of El Tucuché (3,072 feet), one of the two highest peaks in Trinidad, B. W. I., December 15, 1934. The ants were taken at about 10 p. m. as they crawled over the leaves of bromeliads growing close to the ground in the dripping wet, mossy rain forest. Tree frogs (*Amphodus auratus*, *Eleutherodactylus urichi*, and *Gastrotheca fitzgeraldi*) were also out on the leaves and snapped up passing ants but the stomachs of those examined did not contain the Acanthoponeras.

Of the two known species of the subgenus *Acanthoponera* in the New World with their two varieties and a subspecies, this new species is closest to *goeldii* ssp. *schwarzi* Wheeler which is known from the single worker taken in Guatemala. These are the two smallest forms and are closely related. From *schwarzi* (comparing with the type in the Museum of Comparative Zoology) this new species differs in possessing stouter epinotal spines, less deflected petiolar spine, coarser sculpturing of head and thorax, less pilose head, and in darker color.

Thaumatomyrmex

The five species of *Thaumatomyrmex* may be separated by means of the following key:

1. Apical teeth of closed mandibles not exceeding lateral margins of head..... 2
   Apical teeth of closed mandibles exceeding lateral margins of head..... 3
2. A basal fourth tooth on mandible lacking. Cuba.....**cochlearis** Creighton
   A basal fourth tooth on mandible present. Brazil.....**mutilatus** Mayr
3. Lateral margins of head strongly diverging anteriorly. Bolivia..**manni** Weber
   Lateral margins of head moderately divergent..... 4
4. Third tooth, when mandibles closed, barely reaching mid-line of head.
   Honduras.....**ferox** Mann
   Third tooth, when mandibles closed, distinctly exceeding mid-line of head.
   British Guiana and Trinidad.....**atrox** Weber

Thaumatomyrmex atrox, sp. nov.

(Fig. 3)

Worker.—Length about 4.4 mm. Head, between anterior clypeal margin and occiput, three-fourths as long as wide between outer margins of eyes; anterior and posterior clypeal margins convex; sides of head distinctly converging back of eyes; posterior margin concave, occipital corners smoothly rounded. Mandibles with three long, acute teeth and a rudimentary basal fourth in the form of a flattened, acute tubercle. Antennal scapes curved, distinctly exceeding occiput. Thorax from above with sides of pronotum distinctly more convex and broader than rest of thorax. Petiole from above much broader behind, with transverse posterior margin and sides converging in slight convexity to concave anterior margin. Gaster large, with truncate anterior margin. Legs moderately long and slender.

Body smooth and shining except for fine, short vermiculate impressions resembling a very sparse, appressed pubescence.

Pilosity of very sparse, obtuse and coarse reclinate hairs, most numerous and backwardly directed on gaster, shorter and appressed on appendages, becoming a finer pubescence on antennal tips.

Color shining black with pale brown appendages, including mandibles.

Described from one worker (holotype) taken by myself on Kartabo Point, at the junction of the Mazaruni and Cuyuni Rivers, British Guiana, August 20, 1935, and one worker (metatype) taken by myself in the foothills north of Tunapuna, Trinidad, B. W. I., July 29, 1935. Intensive collecting in both localities failed to reveal other workers and testifies to the extreme rarity of these archaic ants. Both specimens were among leaves and, as there were no land snails in either place, a snail-eating habit could not be inferred (cf. Creighton, 1928). It is more probable that the bizarre mandibles are used for capturing other Arthropods (cf. the myriapod-eating habit of *Emeryella schmitti* discovered by Dr. Mann (Wheeler and Mann, 1914). Similar bizarre mandibles are common in *Strumigenys* and I have found a *Strumigenys* worker carrying

a collembolan (*Entomobrya* sp.), controvening a theory that the ants of this genus fed on fungi.

Of the previously known three species this new species is closest to *T. ferox* discovered by Dr. W. M. Mann in Honduras. It is larger than *cochlearis* or *mutilatus* and smaller than *ferox*. From *cochlearis* it differs further in lacking punctate sculpturing on body and fine ridges radiating back from clypeus, in proportions of thorax and petiole, in more anteriorly diverging head, and in mandibular teeth proportions. A cotype of *ferox* differs from this new species in having the pronotum more convex laterally, in having an even convexity between the pro- and mesonotum, in having the petiole more bi-convex and less plano-convex when viewed laterally, in having distinctly thicker petiole apex, in having a shorter head and in mandibular teeth proportions. Sculpturing and pilosity are similar.

Dr. W. M. Mann kindly allows me to describe a fifth species which he took at Huachi Beni, Bolivia:

Thaumatomyrmex manni sp. nov.

Worker.—Length about 4 mm. Head with sides strongly diverging anteriorly. Apical tooth, when the mandibles are closed, far exceeding the sides of the head; third tooth slightly exceeding mid-line of head. Meso-epinotal impression distinct. Epinotal declivity plane. Integument smooth. Pilosity sparse. Color black with pale brown mandibular teeth.

Holotype in the U. S. National Museum. Nidotypes were not at the time available for examination. This species is easily separated from the other species by the strongly diverging sides of the head.

Discothyrea

The three hitherto known New World species of *Discothyrea* and the three species described below may be separated by means of the following key:

1. Antennae nine-jointed 2
   Antennae seven-jointed 3
2. Length of female 1.2 mm. Costa Rica ..... **horni** Menozzi
   Length of female 2 mm., worker 1.5 mm. "North America" .... **testacea** Roger
3. Clypeal lamina between the antennal bases bearing a denticle, worker 1.0 mm. British Guiana ..... **denticulata** Weber
   Clypeal lamina not toothed 4
4. Length of female 1.8 mm. Argentina ..... **neotropica** Bruch
   Length of female 1.1–1.2 mm 5
5. Ventral lamina of petiole with right posterior angle, petiole 0.19 mm. high, node of petiole more sharply angulate above, color lighter. Panama, **humilis** Weber
   Ventral lamina of petiole with acute posterior angle, petiole 0.21 mm. high, node of petiole more rounded above, color darker. Trinidad .... **icta** Weber

Discothyrea humilis, sp. nov.

Female (*Dealate*).—Length, 1.16 mm. Head, excluding mandibles, about one and one-tenth longer than broad back of eyes, evenly rounded, viewed anteriorly, but for feebly concave clypeal margin and slightly flattened occiput; between the antennal bases projects a small triangular plate with rounded apex; eyes large, feebly convex, separated from the mandibular insertions by a distance equal to less than their diameter; ocelli large and prominent; mandibles trigonal with concave masticatory margin bounded apically by a large acute tooth, basally by an acute denticle; antennae 7-jointed, scapes clavate, about three-fifths as long as funiculi, terminal funicular joint 0.17 x 0.10 mm., distinctly longer than remainder of funiculus. Pronotum evenly convex anteriorly. Epinotum distinctly gibbous on each side. Petiole in profile with cuneate node, ventrally with a high rectangular lamina. 1st gastric segment with anterior margin impressed at junction with petiole and sloping downwards and backwards. 2nd gastric segment larger than 1st and overarching the remaining segments; sting fine, short, exserted. Legs small and short.

Surface of body sub-lucid, microscopically reticulate.

Pilosity a fine, whitish, moderately abundant pubescence.

Yellowish-brown.

Described from two dealate females taken by myself June 13 and June 20, 1938, on Barro Colorado Island, Panama Canal Zone. One female was found among decayed leaves and humus on a fallen log, the other in debris swept down by a swollen stream from the forest.

Discothyrea denticulata, sp. nov.

(Fig. 4)

Worker.—Length, 1.0 mm. Head, excluding mandibles, one-tenth longer than wide; in front view sub-circular in outline with occipital margin transverse in middle; antennae 7-jointed, scapes inserted closely together and separated only by a vertical plate which in side view appears as a forwardly directed rectangular plate bearing an acute tooth in front. Eyes small, situated much closer to mandibular insertions than to occipital angles. Mandibles triangular, edentate. Antennal scapes clavate; funiculi with terminal joint ovate and distinctly longer than remainder of joints taken together. Thorax from above widest in pronotal region with sides converging posteriorly to epinotum. Epinotal spiracles projecting as tubercles; declivous surface of epinotum slightly concave and bordered by feeble, rounded carinae. Petiole from above transversely rectangular with rounded corners. 1st gastric segment from above truncate anteriorly, with rounded corners. Legs of moderate proportions.

Entire surface, including gaster and appendages, dull, finely punctate. Entire surface covered with a microscopically fine and appressed pupescence, without erect hairs.

Color uniformly light brown.

Described from one worker taken by myself in virgin greenheart (*Nectandra Rodei* Schomb.) forest near the Forest Settlement, Mazaruni River, British Guiana, Aug. 23, 1935. The ant was among leaves on the forest floor.[4]

This species differs from *D. horni* Menozzi from Costa Rica and *D. testacea* Roger from "North America" (genotype) in possessing seven instead of nine antennal joints. From the female of *D. neotropica* Bruch of the Argentine this species differs in proportions of antennal joints and in having the plate between the antennal scape bases toothed. Of *neotropica* (known only from the type female) Dr. Bruch writes (Bruch, 1919) "Respecto al número reducido de los artejos antenales en *D. neotropica* (9 en el genotipo), he creído bien consultar al Dr. Santschi de Kairouan. Mi distinguido colega me aconsejó conservar el nombre generico, y opina que la contracción de estos artejos es tal vez instable, habiéndola observado con *Discothyrea Traegaordhi* Sants., y en una preparación en bálsamo de Canadá, donde no constan sino 6 artejos, los otros todos más o menos soldados e indefinibles." I am therefore leaving this species in the genus *Discothyrea*. The possibility that the genotype, *testacea*, described in 1863 presumably from "North America" and not recorded since, may also show variability in antennal joint number must be entertained. That it cannot be this species is indicated by the size of *testacea* (1.5 mm. for worker, 2 mm. for female), among other differences.

Discothyrea icta, sp. nov.

Female (*Dealate*).—Length, 1.2 mm. Head, excluding mandibles, about one and one-seventh times longer than broad back of eyes, with sides convex, rounding smoothly into convex occipital corners, occipital margin transverse, anterior clypeal margin smoothly impressed medially; between bases of antennae, is a laterally compressed, acute tooth, curved posteriorly, and convex anteriorly; eyes large, feebly convex, separated from the mandibular insertions by a distance equal to less than their diameter; ocelli large and prominent; mandibles trigonal, terminating in acute apical tooth, cutting margin proximally with a much smaller, acute tooth; antennae 7-jointed, scapes clavate, three-fifths as long as funiculi; terminal joint 0.18 x .09 mm., slightly longer than remainder of funicular joints taken together. Thorax from above rectangular, broader through pronotum than through epinotum, the latter deeply and broadly impressed posteriorly, thus forming distinct and projecting rounded angles. Petiole in profile with cuneate node rounded at apex, ventrum with large lamella convex

[4]A second specimen (metatype) was taken by myself twenty-two and one-half miles west of Kartabo Point, British Guiana, September 8, 1935.

in front, slightly concave behind, the two surfaces forming a right angle. 1st gastric segment with anterior vertical face impressed at junction with petiole; 2nd gastric segment larger than 1st, the remaining segments largely retracted beneath 2nd; sting fine, short, exserted. Legs small, moderately short.

Surface of body sub-lucid, smooth but for microscopic punctations.
Pilosity of fine, whitish, appressed pubescence.
Light yellowish brown, eyes and ocellar bases black.

Described from two dealate females taken by myself under leaves at the base of a saman tree (*Pithecolobium saman*) on the grounds of the Imperial College of Tropical Agriculture, St. Augustine, Trinidad, B. W. I., August 3, 1935.

This species is much smaller than the female genotype, *D. testacea*, or the female of Dr. Bruch's species, *D. neotropica*. From *neotropica* it differs further in having a differently shaped projection (frontal carinae) between the antennal bases, in shape of petiole, including the ventral projection, and in relative proportions of the gastric segments. From the worker of *D. denticulata*, sp. nov. the females differ in the shape of the projection between the antennal bases, in proportions of antennal terminal joint, in shape of petiole, including the ventral projection, and in proportions of gastric segments.

Wadeura

Wadeura, gen. nov.

Worker. — Size moderate. Head quadrangular, with rounded occipital corners and impressed occipital margin; eyes absent; clypeus convex in middle; antennae 12-jointed, slender, scapes not reaching occipital margin; mandibles long and narrow with sinuate outer margin, slender, acute apical tooth, and two distinct pre-apical teeth with smaller tooth between the latter. Thorax with higher, convex promesonotal region and lower, more plane epinotum, the latter laterally compressed and without carinae or teeth. Petiole rounded-cuneate, ventrum convex, not dentate. Gaster of moderate proportions with distinct impressions at sutures, sting projecting. Legs moderately short; middle and hind tibiae with two spurs, the outer being simple and small, the inner large and pectinate.

Sculpturing fine, without coarse punctations or rugae.
Pilosity of fine, dense pubescence and sparse, fine, upright hairs.
Color light brown.

Female.—Slightly larger than worker. Winged.

Genotype: **Wadeura guianensis,** sp. nov.

Wadeura is close to *Pseudoponera* of the Indomalayan and Ethiopian regions, to which it runs in the late Dr. Wheeler's key.

It is separated by the absence of eyes and nature of mandibular teeth. Of the two subgenotypes of *Pseudoponera*, *P. amblyops* Emery and *Promyopias silvestrii* Santschi, *Wadeura guianensis* comes closer to *amblyops* in mandibular structure but lacks the well-formed eyes; it comes closer to *silvestrii* in reduction of eyes. *P. silvestrii* was originally described as a subgenus of *Myopias* but may deserve to rank as a distinct genus. The three could then be grouped as follows: *Pseudoponera* (Indo-malayan)—*Wadeura* (Neotropical)—*Promyopias* (Ethiopian) (Fig. 7a-c).

Wadeura guianensis, gen. et sp. nov.
(Figs. 5 and 6)

Worker.—Length, 4.1 mm. Head, excluding mandibles, barely wider than long, roughly quadrangular with rounded corners and feebly concave occipital margin, eyes absent; clypeus obtusely angulate, produced posteriorly as a slight, rounded gibbosity; antennae 12-jointed, antennal scapes curved towards the head, clavate, not quite reaching occipital margin, joints 1–5 of funiculus distinctly longer than broad, 2nd joint as long or longer than 3rd, joints 6–10 nearly as broad as long; mandibles long and narrow, terminating in a slender, acute tooth, their outer margin feebly sinuate, their inner margin on the distal three-fifths armed with two large but obtuse teeth with a much smaller tooth between; near the base and distal to the subapical tooth a slight rounded tubercle suggests a rudimentary tooth. Pronotum from above lunate, with backwardly directed horns, distinctly wider than mesonotum and about one and one-half times as wide as epinotum; pro-mesonotal impression not distinct; meso-epinotal suture laterally impressed; basal (dorsal) surface of epinotum straight and distinctly lower than thorax, with rounded angles. Petiole cuneiform with rounded apex and a nearly vertical posterior surface, from above transversely trapezoidal with rounded angles. 1st gastric segment from above broader than long, 2nd gastric segment one and three-fourths times broader than long and distinctly the widest segment. Legs of moderate proportions.

Integument feebly shining. Head densely and finely reticulate, thorax, gaster, and appendages with shallow and sparse setigerous punctations which are coarsest on the antennal scapes; mandibles shining with sparse setigerous punctations.

Pilosity of long, fine and upright hairs, sparsest on posterior part of head and on thorax, and moderately abundant appressed pubescence which is thickest on head and appendages.

Color yellowish brown with golden-yellow pilosity.

Described from one worker taken by myself Aug. 2, 1936, near the Oronoque River of the Courantyne River basin in British Guiana in about Latitude 2° 42′ North. A small colony consisting of a half dozen workers, a queen and larvae was found a few centimeters down in sandy loam in high rain forest with

many Brazil-nut trees (*Bertholletia excelsa* or *nobilis*). The nest was in the form of irregular chambers. The queen had a larger thorax than the workers and had evidently borne wings. The entire colony was gathered and the worker here described was preserved. The remainder of the colony with queen and brood was taken by airplane and steamer to New York safely alive. Here they were turned over to Dr. Caryl P. Haskins for study but during his unavoidable absence at one time the entire colony died and was lost.

Wadeura haskinsi, sp. nov.
(Fig. 7, b)

Worker.—Length, 4.4–4.6 mm. Head, excluding mandibles, distinctly longer than broad, roughly quadrangular with rounded corners and slightly impressed occipital margin. Antennal scapes failing to reach occipital margin by a distance greater than their distal diameter; 2nd joint of funiculus shorter than third; mandibles long and narrow, terminating in a slender, acute tooth, their outer margin feebly sinuate, their inner margin on the distal three-fifths with two large, stout, and blunt teeth, of which the more distal is larger, and a small median tooth between them; between the apical and the sub-apical tooth a slight rounded tubercle suggests a rudimentary tooth. Thorax in profile with distinct pro-mesonotal impression.

Other characters as in *W. guianensis*.

Described from three workers taken by my friend, Dr. Caryl Parker Haskins, who found these ants upon several occasions on Barro Colorado Island, Canal Zone and who successfully brought parts of colonies to the United States for study.

This species is close to *W. guianensis* but differs in larger size, mandibular tooth structure, shorter antennal scape, shorter 2nd joint of funiculus, and more distinct pro-mesonotal impression.

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FOUR NEW SPECIES OF DROSOPHILA, WITH NOTES ON THE FUNEBRIS GROUP

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Two of the species herein described, *Drosophila subfunebris*, n. sp., and *Drosophila macrospina*, n. sp., appear to be closely related to *Drosophila funebris* Fabricius, type species of the genus. *Drosophila funebris* has been used extensively in genetic studies by H. A. and N. W. Timofeeff-Ressovsky (1926), Spencer (1928), Romaschoff and Balkashina (1931) and others. Over one hundred mutant types have been recorded. In general the nature of these mutations, at least in their phenotypic expression, differs markedly from that of mutations found in other species of the genus, i. e., *melanogaster* Meig., *virilis* Sturt., *pseudoobscura*, *hydei* Sturt., *ananassae*, *simulans* Sturt. and *willistoni*.

N. W. Timofeeff-Ressovsky (1936) summarizes the qualitative differences in the mutability of *funebris*. Of 83 mutants in this species recorded by Spencer and Timofeeff-Ressovsky only 21.7% showed 100% expression in homozygous stocks. In contrast, of 107 mutants found by the same workers in other *Drosophila* species 67.3% gave 100% expression in homozygous stocks. Of 502 mutants in *melanogaster* 17.2% are dominants. Of 94 mutants in *funebris* 41.5% are dominants. Body and eye color mutants constitute about 3% of the total in *funebris* and about 25% of the total in *melanogaster*. In contrast approximately 35% of the mutants in *funebris* affect the wing veins as against 7% in *melanogaster*. H. A. Timofeeff-Ressovsky (1930) has reported a similar trend in X-ray induced mutants. Many of the genetic loci which mutate rather frequently in other *Drosophila* species appear to have a very low mutation rate in *funebris*. It does not seem valid, however, to conclude in the light of data collected that the total mutation rate of the species is markedly lower than that of others. The difference seems to be largely a qualitative rather than a quantitative one. Recent quantitative studies by Keller and Luers (1937) on mutation rate in *funebris* following different X-ray dosages substantiate this conclusion. In view of the peculiarities noted above the discovery of two species closely related to *funebris* should be of interest to geneticists as well as taxonomists.

Drosophila funebris is widely distributed throughout the temperate regions of the world. Sturtevant (1921) states of its breeding and feeding habits, "In nature it is not so frequently to be found about fruit as are many other species. I have found that stables are very favorable places to collect it, and it is almost certain to appear about animal matter that has been preserved in formalin and then allowed to become somewhat stale. It will breed freely in such material. It will breed in fleshy fungi, but is rarely found about them in the woods. It is, in fact, seldom to be found in the woods at all, though quite common about houses, barns, or grocery stores." We have found it feeding on bleeding trees, and breeding in walnut hulls. In experiments on preference of *Drosophila* species for different baits we find that *funebris* comes readily to traps containing fleshy fungi. Where such traps are exposed along with fermenting banana or other fruit traps the fungus traps collect relatively more *funebris*. In view of the almost constant associations with the habitations of man and its rarity in woods it would seem to be an introduced species in the United States. Its reactions to baits indicate that in its native habitat it is probably a fungus feeder. This species is very easy to culture in the laboratory. Once a culture on either cornmeal, molasses agar, banana agar, or various other media is started it can be kept going almost indefinitely by the occasional addition of a chunk of food. *Funebris* is best cultured at about 22 or 23 degrees Centigrade. The females, in contrast to those of many other species, continue to lay eggs in old cultures and the larvae can secure nourishment from old worked-over media, on which most species would starve. Probably the most important single factor in laboratory culture of this species is not to expose it to temperatures above 24 degrees Centigrade.

One of us has cultured *macrospina* for over two years and *subfunebris* for over a year. The breeding habits in laboratory culture are very similar to those of *funebris*. Both of the new species require that the adults be aged two or three days longer before they breed. *Funebris* starts to lay fertile eggs on the third day after emergence of the adults under optimum conditions. It can complete the life cycle in fourteen days; the other two species require about seventeen days, the difference coming in the aging period of the adults. Neither of the two new species are quite as easy to rear as *funebris*. Both seem to require a higher protein content in the diet.

Macrospina has the peculiar habit of falling into a "catyleptic fit" when the culture bottle is jarred; the flies remain motionless for a minute or so and then begin to move about normally. In *funebris* Spencer (unpublished) has found a mutant showing similar behavior, but more extreme, which arose in the laboratory in a strain after it had been inbred for years. *Subfunebris* walks about the culture bottle very deliberately, with a dainty, mincing gait, while *macrospina* is more active than either of the others.

The taxonomic description of *Drosophila funebris* Fabricius from Sturtevant's monograph (1921) has been included for completeness and the other descriptions are modelled after this. Where possible quantitative characters are used. Recent collections by Dobzhansky, Sturtevant, and ourselves indicate that there are many undescribed species and sub-species of the genus even in regions previously collected. The taxonomy will best be worked out by concentrating on small sub-groups. In some of these one set of characters proves particularly valuable for taxonomic purposes, i. e., sex combs in the *affinis* group (Sturtevant and Dobzhansky, 1936). In the *funebris* group the plates of the male and female external genitalia differ markedly in the three species. It is extremely difficult to separate the specimens of *funebris* and *subfunebris* of either sex on other characters, but reference to the genital plates makes the classification easy. Furthermore, these plates can be observed in living flies under ether, without recourse to dissection.

Descriptions of *chagrinensis*, n. sp., and *magnafumosa*, n. sp., from single collected specimens have been included in this paper because they appear to be fungus feeders not closely related to any of the known sub-groups of the genus.

TAXONOMIC DESCRIPTIONS

The following taxonomic description of *Drosophila funebris* Fabricius is taken from Sturtevant's (1921) "The North American Species of Drosophila," p. 84:

Drosophila funebris Fabr.

(Figs. 1 and 2)

"*Male, female.* Arista with about six branches above and four below, antennae yellow, third joint brown. Front about one-half width of head, wider above; yellowish brown. Second orbital about one-half

third, which is about three-fourths first. Second oral bristle over one-half first. Carina broad, flat; face yellowish brown. Cheeks yellow; their greatest width about one-fourth greatest diameter of eyes. Eyes clothed with thick pile.

"Acrostichal hairs in six rows; no prescutellars. There are several enlarged hairs in front of the two pairs of dorsocentral bristles, and in the same rows with them. Mesonotum and scutellum slightly shining reddish brown. Pleura yellowish brown above, becoming yellow below. Legs yellow. Apical and preapical bristles on first and second tibiae, preapicals on third.

"Abdomen, in the male, shining black; basal segments with a narrow yellow posterior line, and brownish basally. In the female, the abdomen usually appears largely brown in pinned material. In life it can be seen to be yellowish brown, each segment having a posterior dark brown band.

"Wings clear, veins brown. Costal index about 3.9; fourth-vein index about 1.4; 5x index about 1.1; 4c index about 0.6.

"Length body 2.5 mm.; wing 2.5 mm."

Drosophila subfunebris, n. sp.

(Described from living material. Figs. 3 and 4)

Male. Arista with about six branches above and three below. Antennae brown, third joint slightly darker, clothed with short, white hairs. Second oral bristle more than half length of first. Second orbital almost one-half length of third which is two-thirds length of first. Carina high and prominent, especially below; face yellowish brown. Front more than one-third width of head, wider above, velvety brown. Cheeks shining yellowish brown, their greatest width about one-fifth greatest diameter of the eyes. Eyes with rather heavy black pile.

Acrostichal hairs in eight rows, no prescutellars. Several enlarged hairs in front of anterior dorsocentrals, and in the same rows with them. Mesonotum and scutellum brown. Former with darker median stripe. Mesonotum slightly pollinose laterally, scutellum slightly pollinose over entire surface of disc. Legs and pleurae brownish yellow.

Abdomen shining brownish black.

Wings clear, two bristles at distal costal break. Costal index about 3.2; fourth-vein index about 1.4; 5x index about 1.0; 4c index about 0.8.

Length body 3.0 mm.; wing 2.8 mm.

Female. Same as above except abdomen shining blackish brown, each segment darker posteriorly.

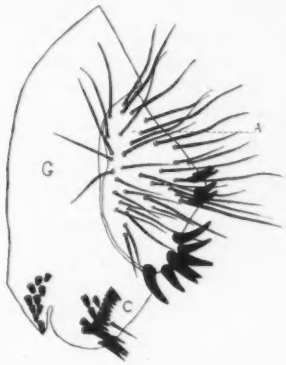
Length body 3.4 mm.; wing 3.0 mm.

EXPLANATION OF FIGURES

Fig. 1. Ovipositor plate of female *D. funebris.*
Fig. 2. Male external genitalia of *D. funebris.*
Fig. 3. Ovipositor plate of female *D. subfunebris* n. sp.
Fig. 4. Male external genitalia of *D. subfunebris* n. sp.
Fig. 5. Ovipositor plate of female *D. macrospina* n. sp.
Fig. 6. Male external genitalia of *D. macrospina* n. sp.

A—anal plate. G—genital arch. C—clasper.

1



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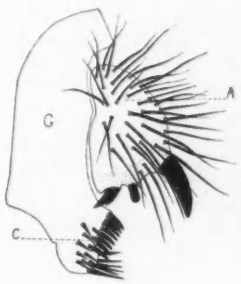

6

Scale in μ

Subfunebris is approximately the same size as *funebris*. Our measurements of body and wing length on species described by Sturtevant run consistantly higher than his.

Sturtevant's description of *funebris* mentions it as having six rather than eight acrostichal rows. This is doubtless a typographical error.

Type and *gonotypes* from descendants of fertilized female collected at Pasadena, California, May 5, 1937 (W. P. Spencer).

Other collection records: Pasadena, California, November 19, 21, 28, 1936 (W. P. Spencer); Camp Rincon, San Gabriel Mountains, California, April 24, 1937 (W. P. Spencer).

The name *subfunebris* refers to the close relationship of this species with *funebris*.

Drosophila subfunebris differs from *Drosophila funebris* in the following characteristics: Thorax less grayish, shinier. Carina narrower, particularly above. Eyes lighter in color, pile shorter. Thoracic bristles longer and heavier. Legs and pleurae darker. Abdominal banding in female less distinct; dark posterior bands on each segment not interrupted mid-dorsally, or if interrupted, less distinctly so. Structure of external genitalia different in both sexes (see plate). Postero-dorsal angle of ovipositor plate in female not darkened. Walks with a more deliberate, mincing gait.

Drosophila macrospina, n. sp.

(Described from living material. Figs. 5 and 6)

Male. Arista with about five branches above and three below. Antennae yellowish brown, third joint darker, clothed with fine white hairs. Front over one-third width of head, wider above; dark brown. Second orbital less than one-half length of third which is three-quarters length of first. Second oral bristle three-quarters length of first. Carina high and narrow, particularly above, face dull brown, sometimes slightly yellowish. Cheeks shining yellowish brown, their greatest width about one-seventh greatest diameter of the eyes. Eyes pilose.

Acrostichal hairs in eight rows; no prescutellar bristles. Thoracic hairs in dorsocentral rows slightly more regular than acrostichal hairs median to them. Mesonotum dark brown, sometimes almost black; slightly pollinose, especially laterally. Scutellum pollinose, blackish brown. Pleurae and legs yellowish brown.

Abdomen shining brownish black.

Wings clear, two bristles at distal costal break. Costal index about 3.4; fourth-vein index about 1.4; 5x index about 1.4; 4c index about 0.8.

Length body 2.7 mm.; wing 2.5 mm.

Female. Same as above except abdomen shining dark brown, each segment with a paler anterior band.

Length body 3.3 mm.; wing 2.8 mm.

Type and *gonotypes* from stock received from the University of Texas laboratory. This stock was collected at Austin, Texas, in 1935.

Other collection records: Lake Taneycomo, Ozark Mountains, Missouri, June 27, 1937 (W. P. Spencer); North Chagrin Reservation, Cleveland, Ohio, August 25, 1938 (J. V. Neel); Smoky Mountains National Park, Tennessee, July 11, 1938 (W. P. Spencer-H. D. Stalker); Grosse Pointe Shores, Michigan, July 6, 1935 (H. D. Stalker). Both the Ohio and Texas collections were made from fungus, the Michigan, Missouri, and Tennessee collections from fermenting banana.

The name *macrospina* refers to the conspicuous black spine on the anal plate of the male.

Drosophila macrospina differs from *Drosophila funebris* in the following characteristics: Smaller, squattier fly. Thorax darker, especially on sides. Carina narrower below. Hairs on third antennal joint slightly longer. Eyes larger, with shorter pile; cheeks narrower. Eye color lighter; front, legs, and pleurae darker. Female with more distinct abdominal banding. Structure of external genitalia different in both sexes (see plate). Ovipositor plate in female darkened both postero-dorsally and antero-ventrally, not just postero-dorsally as in *funebris*. Subject to "catyleptic fits" when container is disturbed.

Drosophila macrospina differs from *Drosophila subfunebris* in the following characteristics: Smaller, squattier fly, more size difference between the male and female. Thorax darker in color, thoracic pattern less distinct. Female with more distinct abdominal banding. Cheek narrower; eyes larger, with thinner pile and a lighter color. Carina narrower below; hairs on third antennal joint slightly shorter. Front darker. Structure of external genitalia different in both sexes (see plate). Ovipositor plate darker. Subject to "catyleptic fits" when the container is disturbed. Does not walk deliberately, with a mincing gait.

The eggs of all three of the above species have four filaments.

Drosophila chagrinensis, n. sp.

(Described from pinned material)

Female. Arista with six branches above, and one below. Antennae brown, third joint darker, almost black, clothed with long yellow hairs. Carina low and narrow, confined to upper part of face; face yellowish brown. Front over one-third width of head, wider above, brown, lighter

anteriorly; orbits shining brown. Second orbital less than one-half length of other two. Only one prominent oral bristle. Cheeks light brown, their greatest width one-fourth greatest diameter of eyes. Eyes with thin, sparse pile.

Acrostichal hairs in six rows, no prescutellars. Mesonotum and scutellum brown, slightly shining. Mesonotum somewhat pollinose laterally, scutellum slightly pollinose over whole surface of disc. Mesonotum with two light stripes along dorso-central rows, two dark stripes just inside dorsocentral rows, and light area between these inner stripes. Anterior scutellar bristles divergent. Pleurae dark brown, legs yellowish brown.

Abdomen shining brownish-yellow, each segment with a dark brown posterior band.

Wings clear, with single bristle at the distal costal break. Costal index about 2.5; fourth-vein index about 1.6; 5x index about 1.5; 4c index about 0.9.

Length body 2.8 mm.; wing 2.6 mm.

Type and only specimen taken from fleshy fungus in North Chagrin Reservation, Cleveland, Ohio, July 27, 1937 (H. D. Stalker).

The name *chagrinensis* refers to the type locality.

Drosophila magnafumosa, n. sp.

(Described from pinned material)

Male. Arista with five branches above and one below. Antennae brownish yellow, third joint darker. Carina fairly prominent, face yellow. Second orbital one-third size of other two. Only one prominent oral bristle. Front over one-third width of head, wider above, velvety yellowish brown; orbits shining. Cheeks dull brownish yellow, their greatest width one-fourth the greatest diameter of the eyes. Eyes with blond pile.

Acrostichal hairs in six rows, no prescutellars. Anterior dorsocentrals very close to posterior dorsocentrals. Bristles on sides of thorax long. Mesonotum and scutellum brownish yellow, somewhat shining, slightly pollinose laterally. Mesonotum with median dark stripe. Anterior scutellars divergent. Pleurae brown, legs brownish yellow.

Abdomen yellowish brown, somewhat shining. Each segment with a posterior black band, widely interrupted mid-dorsally.

Wings clear, only one bristle at distal costal break. Costal index about 3.0; fourth-vein index about 1.5; 5x index about 1.7; 4c index about 0.9.

Length body 2.8 mm.; wing 3.0 mm.

Type and only specimen taken from fleshy fungus in Smoky Mountains National Park, Tennessee, at an elevation of 4,000 ft., July 11, 1938 (W. P. Spencer).

The name *magnafumosa* refers to the type locality.

NEW AND LITTLE KNOWN WESTERN PIPUNCULIDAE[1] (Diptera)

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Studies of larvae of big-eyed flies as parasites of the sugar-beet leafhopper, *Eutettix tenellus* (Baker), have been carried on by the Utah Agricultural Experiment Station during the past ten years in co-operation with the United States Bureau of Entomology and Plant Quarantine. Several of the species here discussed were collected or reared in connection with the beet-leafhopper investigations and are of importance in the biological control of this pest.[3] A study of available material indicates that many of the species of Pipunculidae occurring in Utah are as yet undescribed.[4]

Pipunculus confraternus melanis n. var.

This variety conforms structurally to *confraternus* Banks and *tarsalis* Banks but differs in having the femora black except for narrow yellow apices; tibiae blackened medially, halteres more yellowed, stigma shorter than fourth costal section of wing and anal cell with a rather long petiole.

Male.—Front and face silvery, vertex shining black, occiput gray pollinose. Second joint of antennae (fig. 2) black, third brownish with yellowish-white acuminate tip; arista black, base broad, not elongate as in *confraternus*. Dorsum of thorax and scutellum subopaque, brownish black, cinereous on the lateral margins, also pleura and coxae. Humeri yellowish-white. Halteres brown basally, stems whitish, knobs yellow-brown. Trochanters and femora black, dusted with gray pollen, apices of femora narrowly yellowed. Tibiae and tarsi chiefly yellow, the former somewhat blackened medially. Femoral bristles not pronounced, tibiae and tarsi with numerous rows of short brown bristles. Abdomen (fig. 1) shining to subshining on the dorsum, lightly pruinose on the lateral margins and posterior edge of first segment, broadest at sides of third segment. Fifth segment of abdomen about one and one-half times as long as fourth. Lateral comb of abdomen composed of several rather

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[3]Knowlton, G. F., Biological Control of the Beet Leafhopper in Utah. Proc. Utah Acad. Sci. Arts and Letters, 14: 111–116, 1937.

[4]The writers are indebted to M. W. Allen, graduate assistant in entomology, for assistance in preparing the figures. Authorized for publication.

long black hairs. Hypopygium more shining, broad, oval, and without cleft, about one and one-half times as large as fifth segment; the ventral lobe yellow, extending to anterior margin of fourth sternite.

Wings hyaline, stigma blackish, about three-fourths as long as fourth costal section; r-m crossvein situated opposite end of auxiliary vein and at basal one-fourth of discal cell. Last section of fifth shorter than posterior crossvein; anal cell with comparatively long petiole (fig. 3).

Length: wing 3.5–4 mm., body 3.2–3.5 mm.

Female.—The female is somewhat more cinereous on the sides of the abdomen and has the acuminate portion of the antennae more whitish. The yellow ovipositor is very narrow and sharply pointed but slightly longer than its base; the base is short and not enlarged. The front is chiefly shining black, silvery just above antennae. Occiput dull black above, silvery on sides.

Holotype, male collected on *Chrysothamnus nauseosus* at Chicken Creek Reservoir, Utah, August 17, 1938 (G. F. Knowlton-F. C. Harmston); *allotype*, female, LaSal Junction, Utah, July 28, 1938 (Knowlton-Harmston); paratypes, 25 females and 27 males from the following Utah localities: Reared from *Eutettix tenellus* (Baker) collected at West Mountain west of Payson, September 23, 1937 (H. E. Dorst-M. W. Allen); Bluffdale, Collinston, Elberta, Evans, Fort Duchesne, Magna, Mendon, Midvale, Pleasant View, Salem, Sterling, and on beets at Bothwell (Knowlton); Woodside (D. E. Hardy-A. T. Hardy); Huntsville and Laketown (Knowlton-D. E. Hardy); Grantsville and Dolomite (Knowlton-C. F. Smith); Syracuse, and among potato vines at Thatcher (Smith); Greendale, Jensen, south of LaSal and LaSal Junction in meadow, Miners Basin, LaSal Mountains, Moab and Monticello (Knowlton-Harmston); Brigham and Salt Lake City (Knowlton-G. S. Stains); on peas at Liberty (Hardy-Stains); on beets at Farmington (M. F. Bowen). Also in Colorado at Avondale, September 6, 1938 (Hardy-A. T. Hardy); Beulah, Colorado and Manhattan, Kansas (R. H. Painter); and Clowdcroft, New Mexico (R. H. Beamer).

Pipunculus femoratus apicarinus n. var.

This species seems, morphologically, close enough to *femoratus* Cresson to belong to that species. It differs from the typical variety in having the third segment of the antennae brownish black. Stigma and third costal section longer than fourth section of costa (fig. 5). Thorax with two faint median vittae and posterior femora swollen but not so strongly incrassate.

Male.—Front, face and occiput silvery, antennae dark brownish to black, second segment with a faint yellowish tinge; third segment conically acute as in typical variety. Halteres and humeri bright yellow. Mesonotum and scutellum with brownish yellow pollen, grayish on the sides with two faint grayish vittae longitudinally. Pleurae and metanotum cinereous, occiput, dorsum of thorax and abdomen covered with fine short yellow hairs, less dense on the abdomen. Coxae black, the rest of legs yellow, except for the brownish median portions of the femora. Mesothoracic coxae with several long hairs apically, meso- and meta-thoracic trochanters each with a few yellow hairs below. Femoral and tibial spines fairly well developed but not so strong as in *femoratus femoratus* Cresson.

Abdomen chiefly shining, first segment whitish pollinose on the sides, somewhat brownish in the middle, other segments only slightly grayed on their sides and anterior margins. Hypopygium almost as large as fifth segment, strongly compressed to the right with an apical cleft and well developed keel (fig. 4).

Wing hyaline, somewhat iridescent, second costal section and colored stigma one and one-half times as long as third section. Ultimate section of fourth vein sinuate. Last section of fourth equal to posterior cross vein. Anal cell with a petiole of medium length; r-m crossvein at or but slightly before end of auxiliary vein and at basal one-fourth to one-third of discal cell.

Holotype, male, Wolf Creek Pass, Utah, August 15, 1937 (G. F. Knowlton-F. C. Harmston).

Pipunculus fuscitarsus Adams

Indian Creek, Utah, July 27, 1938 (Knowlton-Harmston); Logan Canyon, Utah, August, 1938 (Hardy-Stains); Logan Canyon, Utah, July, 1937 (Knowlton-Smith-Harmston); and Spring Hollow, Logan Canyon (Hardy-Hardy). Two male specimens from Utah seem to belong to this species.

Pipunculus harmstoni n. sp.

This species is near *fuscitarsus* Adams and *viduus* Cresson but differs from the former in having the antennae short acute, bluntly pointed below; abdomen more shining. Apices of coxae, trochanters and bases of femora bright yellow; all tibiae bowed and having strong flexor bristles; the hypopygium not cleft to the apex (fig. 6). It differs from *viduus* in having the third segment of antennae more obtuse; hypopygium without keel and apical cleft. Halteres black; tibiae and tarsi more yellowed.

Male.—Antennae (fig. 7) shining black; face and front silvery, front slightly raised above antennae and with a narrow black stripe down the middle. Eyes broadly contiguous. Uppermost part of occiput, mesonotum, scutellum and most of abdomen brownish pollinose, very faintly

shining. Two indentations on the sides near the posterior edge of mesonotum. Lower portions of occiput, pleura, coxae, metanotum and sides of abdomen gray pollinose. Humeri whitish, halteres black. Trochanters brownish yellow, apices of trochanters and femora yellow; femora otherwise black, lightly gray dusted. Tibiae and tarsi yellow, tibiae slightly browned medially below. Femoral and tibial bristles weak, posterior tibiae noticeably curved.

Abdomen with fifth segment one and one-half times as long as fourth. Hypopygium about three-fourths as long as fifth, compressed to the left with a basal cleft not extending to the apex (fig. 6), intermediate lobe slightly visible from above. Abdomen as well as thorax chiefly bare.

Wings very lightly browned, darkened stigma; third costal section longer than fourth. Last section of fourth vein almost straight; ultimate section of fifth equal in length to the posterior crossvein. Anal cell with a long petiole; r-m crossvein opposite end of auxiliary vein and at basal one-fourth of discal cell.

Length: Body 3.5 mm., wing, 4.2 mm.

Holotype, male, Millville, Utah, May 10, 1938 (G. F. Knowlton-F. C. Harmston).

Pipunculus lasiofemoratus n. sp.

Near *nigripes* Loew but the colored stigma is not more than one-half the length of the fourth costal section. Posterior femora densely haired on under side (fig. 10) and the spines well developed on the mid femora. Hypopygium different and with a slight apical keel (fig. 8).

Male.—Eyes joined; face and front silvery, vertex and upper occiput shining black, lower portion of occiput gray. Second segment of antennae black with bristles above and below, third segment acute (fig. 9) tinged with brown but lightly whitish pubescent. Mesonotum and scutellum opaque brownish black, the margins slightly grayed. Pleurae, coxae, humeri and metanotum cinereous; humeri black in ground color. Scutellum sparsely bristled on posterior margin. Knobs of halteres black, stems brownish. Trochanters, femora and tibiae chiefly black with cinereous pollen, their apices, bases of tibiae and of hind femora yellow; the inner edge of the posterior femora brownish and shining. Tarsal segments one to four yellow, fifth brownish; tarsal claws and pulvilli yellow, the claws with black tips. Apical three-fifths of anterior femora with two rows of rather stout flexor spines, mid femora with two rows of spines extending almost to bases. All femora with a row of long bristles toward the dorsal edge on each side. Posterior femora with dense long curved hairs below and a row of long hairs dorsally on the inner side (fig. 10). All tibiae with numerous rows of short spines having short black hairs intermixed and a dense brush of short yellow hairs beneath anteriorly. Pile of tarsi chiefly black above, yellow beneath, posterior tibiae and femora arcuate.

First segment of abdomen silvery gray pollinose on sides and along anterior margin, narrowly interrupted with brown in the center. Seg-

ments two to five finely gray pollinose on the sides and anterior margins with broad interruptions in the middle; abdomen otherwise shining black with a slight brownish tinge. Lateral comb of first abdominal segment composed of long black hairs. Abdomen (fig. 8) with hypopygium small, slightly exceeding one-half length of the fifth segment of the abdomen; apically cleft and with a slight keel; also a smaller cleft basally just to right of center.

Wings (fig. 11) hyaline, the second costal section shorter than third, colored stigma about one-half the length of fourth section.

Holotype, male, Nibley, Utah, July 1, 1938 (D. E. Hardy-A. T. Hardy).

Pipunculus proximus Cresson

This species differs from *similis* Hough in having the third segment of the antennae longer acuminate; third costal section of wing less than one-half the length of the fourth section; hypopygium different, and the post-trochanters with several long bristle-like hairs near the base. The male has the wings dusky fumose while the female wings are more hyaline. The female also differs from *similis* in having the front silvery on lower one-half and having trochanteral hairs. This species was originally described from the female; the following is a description of the male:

Male.—Eyes contiguous above, front and face silvery; occiput silvery below, somewhat shining above. Second antennal segment black with numerous setae and long hairs; third segment fusco-piceous with a hoary tinge and fringe of short pubescence, segment narrow acuminate, slightly curving up at the tip; arista shining black, base swollen.

Thorax and abdomen shining metallic with a greenish luster, anterior margins and side of mesonotum lightly dusted with gray to brown pollen. Humeri and halteres bright yellow, pleurae and metanotum subshining but slightly grayed. Legs black with gray pruinosity except yellow apices of femora and tibiae (bases of tibiae broadly yellow), all tarsal segments yellow; posterior trochanter with a small tuft of bristles basally, usually three to four medium length bristles; posterior tibiae somewhat curved.

Abdomen but slightly ovate, a trifle broader at segments three and four. Segments two to three about equal, segment four slightly longer, segment five approximately one and one-fourth times the length of four. The lateral margins of the abdomen covered with short black hairs, these being longer and more dense on the posterior segments. Lateral comb of first segment black. Posterior portion of abdomen usually curved downward. Hypopygium slightly shorter than fifth segment, compressed to the right and with a basal cleft extending to the apex just off middle on the right side.

Length: Body 3 mm., wing 3.2 mm.

Collected in Utah at: On alfalfa at American Fork, June 25, 1938, Nibley, (Knowlton-Hardy); Deweyville, Fillmore, Granger, Providence and Trenton (Knowlton); Logan Canyon and Spring Hollow of Logan Canyon (D. E. Hardy-A. T. Hardy); Green Canyon, Manila, Indian Creek and Roosevelt (Knowlton-F. C. Harmston); Arthur, Salt Lake City, Strawberry, and Magna (Knowlton-G. S. Stains); Wellsville (C. F. Smith-Harmston); Granite (M. W. Allen); Farmington and Hooper (D. E. Hardy); Manti (L. L. Hansen); and Fielding in beet field (M. F. Bowen). Also collected in Idaho at Geneva, July 29, 1938 (D. L. Bischoff).

Pipunculus proximus flaviantennus n. var.

This differs from typical *proximus* Cresson in having the third segment of the antennae (fig. 15) yellow and the ovipositor of the female more slender (fig. 13). The abdomen (fig. 12) is narrower and not so ovate as in the preceding variety.

Holotype, female, Smithfield, Utah, June 4, 1938 (D. E. Hardy-D. L. Bischoff); allotype, male, Pullman, Washington, May 7, 1918 (No. 965); paratypes, 10 females and two males from: Harrisville, Utah, July 6, 1933 (Knowlton); Midvale, Utah, August 27, 1937 (Knowlton); Logan, Utah, July 28, 1938 (Knowlton); Logan Canyon, Utah, July 4, 1938 (D. E. Hardy-A. T. Hardy). Also Lind, Washington, May 26, 1919 (F. W. Carlson); Pullman, Washington, April 25, 1919; Ewan, Washington, June 13, 1920 (R. C. Shannon); Collins, Idaho, July 27, 1898; and Shellwood, Ontario, July 5 (H. S. Parrish)[5].

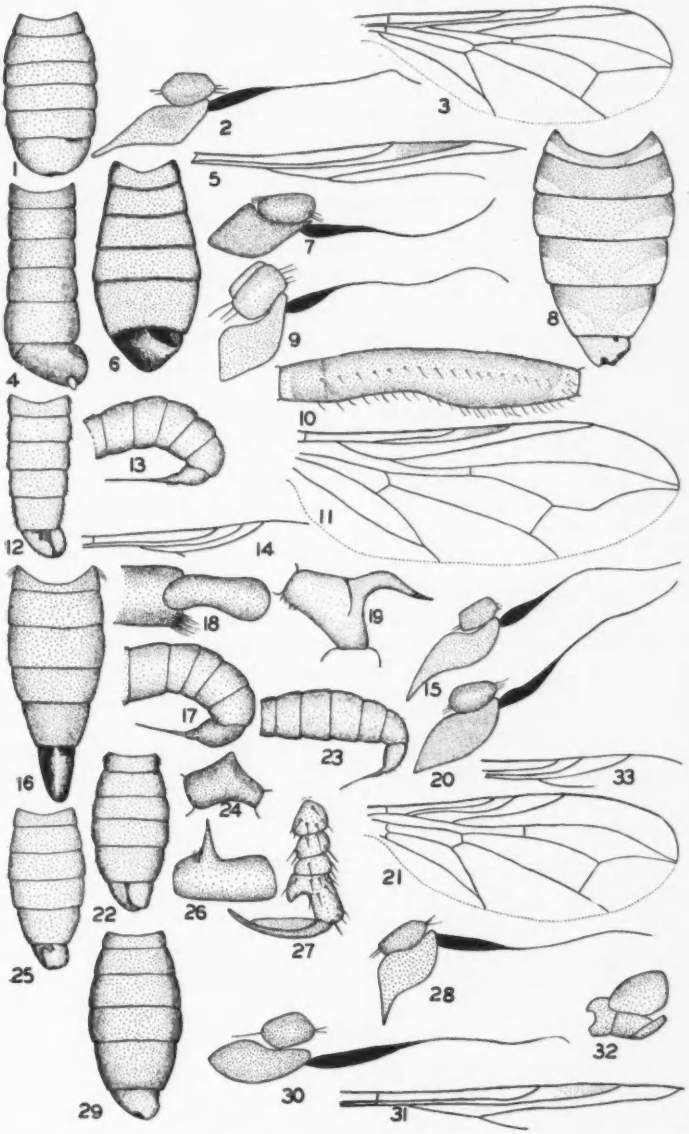
Pipunculus toxodentis n. sp.

The males of this species run to *unguiculatus* Cresson (Cresson, Trans. Amer. Ent. Soc. 36: 277-282, 1911) but differ in having the trochanteral tooth elongate, about as long as trochanter and sharply curved (fig. 19). The female is near *vagabundus* Knab but differs in having a clump of yellow hairs on the

[5]The specimens from Washington, Idaho and Ontario were lent for study through the courtesy of Prof. R. D. Shenefelt, Washington State College.

EXPLANATION OF PLATE

Pipunculus confraternus melanis n. var., 1–3. *P. femoratus apicarinus* n. var., 4–5. *P. harmstoni* n. sp., 6–7. *P. lasiofemoratus* n. sp., 8–11. *P. proximus flaviantennus* n. var., 12–15. *P. toxodentis* n. sp., 16–21. *P. trochanteratus* Malloch, 22–23. *P. trochanteratus tenellus* n. var., 24. *P. utahensis* n. sp., 25–28, 33. *P. varius phaethus* n. var., 29–32.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post-trochanter and two long flexor bristles at bases of front femora.

Male.—Front, face and occiput silvery pruinose. Second segment of antennae black with short black bristles above; third segment acuminate (fig. 20) brownish with hoary tinge, whitish fringed. Humeri and halteres yellow-white, the bases of the halteres brown. Dorsum of thorax sub-shining with gray pollen on the sides and on the scutellum; the entire dorsum of thorax and abdomen rather thickly covered with pale brownish hairs. Pleurae, sternum, coxae and femora (except yellow apices) black, dusted with grayish; meso-coxae with a clump of long black hairs on the inner edge apically (fig. 18). Trochanters more shining, with a long curved tooth on each, near base (fig. 19). Tibiae narrowly yellowed at bases and apices, otherwise black; posterior tibiae but slightly curved. Tarsi yellow, first tarsal segment slightly longer than next three segments and about three times as long as segment five. Spines of femora and tibiae not strongly developed.

Abdomen (fig. 16) covered with short black hair, denser and longer on lateral margins of the posterior segments, the last few segments of abdomen usually curved downward, and the genitalia sometimes curved beneath the abdomen. Abdomen subshining metallic, slightly pruinose on the sides. Lateral comb of first segment composed of numerous long yellow-brown hairs. Hypopygium elongate, slightly longer than fifth segment and tapering to a blunt point (fig. 16), compressed to left but with a small dorsal cleft at middle near the base and extending down right side.

Wings (fig. 21) hyaline with a light brownish tinge, stigma not colored.

Length: Wing 3.2–3.4 mm.; body 3.3–3.5 mm.

Female.—Front silvery to just below ocelli, slightly concave in the middle; occiput dull black above, silvery on the sides, not strongly swollen as in *albiseta* Cresson. Abdomen shining, only dusted on the sides. Piercer of ovipositor elongate, about twice as long as its base and reaching almost to the base of the abdomen (fig. 17) or at least to second segment. Posterior trochanters with a small clump of short yellow hairs basally, beneath, front femora with two long hair-like bristles on the underside near bases.

Holotype, male, Salt Lake City, Utah, August 5, 1938 (G. F. Knowlton-G. S. Stains); *allotype*, female, Bluffdale, Utah, July 28, 1938 (Knowlton-F. C. Harmston); paratypes, 16 males and 12 females taken in Utah from: Bluffdale, July 28, 1938 (Knowlton-Harmston); Logan Canyon, July 10, 1938 (D. E. Hardy-A. T. Hardy); Brigham and Garland (Knowlton-D. E. Hardy); Salt Lake City, August 5, 1938 (Knowlton-G. S. Stains); Taylorsville, September, 1937 (Knowlton-Harmston); Salem, West Weber and Nephi, (Knowlton); Spanish Fork, September 2, 1938 (Hardy-C. B. Corbett). In Colorado 10 paratypes from Fruita, Grand Junction, LaJunta and Fowler, September 5 and 6, 1938 (D. E. Hardy-A. T. Hardy).

Pipunculus trochanteratus Malloch

The female of this species is apparently undescribed. The following short discussion enumerates the characters which differ from the description of the type male:

Female.—Front silvery for one-third its distance above antennae, verging from dusty to shining black toward the vertex, front widened and somewhat excavated for half its length below the ocelli. Thorax and abdomen very lightly dusted over the shining black ground color, giving a sub-shining appearance. Pile of thorax and abdomen sparse and pale. Combs of first abdominal segment yellow. Sixth segment of abdomen slightly longer than fifth. Base of ovipositor globose, not elongate, with a small tooth-like projection on its underside next to ventral margin of sixth segment (not visible if the ovipositor is folded under) (fig. 23). Piercing organ rather short and narrow, about equal to its base in length, extending to the posterior margin of third segment, abruptly terminating at its base. Post-trochanters with clumps of yellow hair near bases on ventral side. Femora not so swollen as in the male.

Distribution in Utah: Brigham, August 12, 1938 (Knowlton-Hardy); Magna, and Salt Lake City, Utah, August, 1938 (Knowlton-Stains); Fielding, Utah, August 12, 1938 (Knowlton-Hardy). Also collected in Idaho at Coeur de Alene, August 24, 1938 (L. L. Hansen).

In the type male specimen the genitalia was contorted and Malloch was unable to give a description of it. As the specimens at hand definitely appear to be this species the male abdomen is figured here (fig. 22).

Pipunculus trochanteratus tenellus n. var.

This is the most common *Pipunculus* internal parasite of the beet leafhopper occurring in Utah. This variety differs from the typical *trochanteratus* in having the third segment of the antennae yellow and the thorax and abdomen more densely pollinose. The specimens vary from subshining lightly dusted to cinereous thickly covered with coarse pollen. Specimens in good condition (unrubbed) usually have the ground color obscured by pollen, otherwise as in *trochanteratus trochanteratus*.

The females of this variety cannot be separated readily from females of *subnitens* Cresson but the males are very distinctive in having a well developed tubercle on the post-trochanters (fig. 24). The hypopygium is also very different from that of *subnitens*; this is cleft to the base on the left side as compared with the large apical cleft on the right in *subnitens*.

Holotype, male, Mt. Carmel, Utah, June 18, 1935, on *Salsola pestifer* (G. F. Knowlton); *allotype*, female, Mills, Utah, August 17, 1938 (Knowlton); paratypes include 150 specimens from

Utah, a number being reared from the beet leafhopper, *Eutettix tenellus* (Baker) collected at Appledale, September 18, 1936, Blue Creek, Lampo, Little Mountain, Mills, Promontory, and West Mountain (H. E. Dorst-[6]Knowlton-M. W. Allen-C. F. Smith-Hardy). Other Utah localities include: Bothwell, Cedar Spring, Curlew, Delle, on *Bassia* at Dolomite, on Russian thistle at Garfield, Garland, Grantsville, Hardup, Hansel's Valley, Indian Canyon, Kelton, Lampo, Low, Promontory, Roosevelt, Showell, Snowville and Timpie (Knowlton); Hooper (Hardy); Black Rock, Curlew, Grantsville and Orr's Ranch (Knowlton-M. J. Janes); LaSal (Knowlton-Harmston); Promontory and Snowville (M. F. Bowen); Black Rock, on beets at Brigham and Centerville, on *Bassia* and Russian thistle at Dolomite, Garfield, West Mountain, Magna, Mills, Orr's Ranch and Timpie (Knowlton-C. F. Smith). Also collected at Coeur de Alene, Idaho, August 24, 1938 (L. L. Hansen).

Pipunculus utahensis n. sp.

Runs to *unguiculatus* Cresson but differs in having the trochanteral spine more narrow, straight and sharply pointed, dorsum of thorax and abdomen shining metallic and more pilose. Fourth section of costa about three times as long as third; anal cell with a longer petiole and hypopygium differently developed.

Male.—Face silvery, front opaque black, vertex and upper occiput shining. Eyes only joined for a short distance below the ocelli. Occiput broad, usually completely covering the humeri. Antennae black, third segment acuminate, point arising from the lower portion of the segment, rounded above (fig. 28).

Thorax and abdomen shining black, dorsum and pleurae slightly dusted, metanotum cinereous. Humeri grayish, halteres bright yellow. Thorax and abdomen rather densely short black pilose. Legs chiefly shining black. Extreme apices of femora and bases of tibiae yellow, tarsi blackish tinged with yellow. Mid-coxae with several black bristles below. Post-trochanter with a sharply pointed tooth near its base below and a small clump of yellow hairs on the outside edge (fig 26) Posterior tibiae slightly clavate, the narrow basal portion somewhat bowed Fifth segment of anterior tarsi with an unusual development on the inner side near the base (fig 27) claws long, tarsal segments bristly

Abdomen (fig 25) only slightly rounding on its sides Comb of first segment composed of long gray hairs. Hypopygium compressed to the right, with a small cleft just off the middle on the left side extending into a larger apical cleft.

[6]Mr. H. E. Dorst, of the United States Bureau of Entomology and Plant Quarantine, has been located at the Utah Agricultural Experiment Station since September, 1936, co-operating with Utah Station entomologists in investigations of the beet leafhopper and the tomato fruitworm.

Wings (fig. 33) hyaline, last section of fourth vein slightly sinuate. Petiole of anal cell long; r-m crossvein, situated about midway between first and second veins and at about middle of discal cell.

Length: wing, 3.2 mm.; body, 2.8 mm.

Female.—Face and lower portion of front silvery, upper one-third to one-half of front shining black with a narrow shining ridge extending from the ocelli one-fourth the distance of the front. Occiput very broad shining black above, silvery on the sides. Front femora with two long flexor hairs on the underside near bases; hind trochanters with small clumps of short bristles beneath. Abdomen sub-ovate, the sides broadly rounding; piercer of ovipositor slender extending to second segment and abruptly terminating its globose base. Otherwise like the male.

The female of this species keys out with *similis* Hough. The abdominal segments are not noticeably constricted at the incisures and the ovipositor reaches only to the posterior edge of the second segment; these characters, however are not sufficient to conveniently separate the species; *similis* has not been observed, by the writers, west of Kansas and is probably not found in Utah.

Holotype male, Lehi, Utah, July 20, 1938 (Knowlton); *allotype*, female, Johnson, Utah, September 12, 1938 (Knowlton-Harmston); paratype males, Bluffdale, Utah, July 20, 1938 (Knowlton); Spanish Fork, Utah, September 2, 1938 (Hardy-C. B. Corbett); Dry Lake, Sardine Canyon, Utah, September 2, 1938 (Knowlton-R. E. Nye).

Pipunculus varius Banks

Described from male, female apparently undescribed. The writers have examined specimens of males which fit the description of *varius*. Only one female has been observed and this fits the description of *horvathi* Kertesz. Further studies may show *varius* to be a synonym of *horvathi*.

Pipunculus varius phaethus n. var.

Differs from the typical variety in having the antennae black.

Male.—Second segment of antennae short acute, black with two to three hairs above and a number of short bristles below; third segment brownish, white fringed on margins; arista pale yellow basally, otherwise shining black (fig. 30). Halteres yellow, knobs slightly darker.

Mesonotum and scutellum subshining with fine brownish yellow pubescence, lateral margins, humeri, pleurae and metanotum cinereous. Coxae shining black, trochanters yellow; femora, tibiae and tarsi chiefly yellow, femora with broad black rings at their middles, tarsal segments four and five slightly brownish. Middle trochanters with a long yellow

hair above. All femora with a row of fine yellow hairs on the sides slightly dorsal (these are sometimes difficult to discern); femoral spines developed on anterior half, posterior tibiae slightly arcuate.

Abdomen (fig. 29) chiefly shining black, first segment cinereous, second segment opaque basally, subshining apically, other segments polished and metallic. Hairs of lateral comb on first segment yellow (on one paratype the combs are black.) Hypopygium shining but slightly dusted, compressed to the right; rather small from dorsal view. Ventral processes developed, reaching to base of fifth segment (fig. 32). Hypopygium with an apical cleft barely visible in dorsal view (fig. 29).

Wings hyaline with a slight iridescent tinge (fig. 31); ultimate section of fourth vein straight or nearly so. Last section of fifth vein slightly sub-equal to posterior crossvein. Anal cell with a long petiole. Crossvein r-m slightly beyond end of auxiliary vein and basal one-third of discal cell.

Length: wing, 4.5–5 mm.; body approximately 4 mm.

Female unknown.

Holotype, male, Paradise, Utah, June 14, 1938 (D. E. Hardy-G. S. Stains). Three *paratype* males, Logan Canyon, Utah, July 10, and August 7, 1938 (D. E. Hardy and A. T. Hardy); Wolf Creek Pass, Utah, September 1, 1937 (Knowlton-F. C. Harmston).

Types: Most of the types will be deposited in the U. S. National Museum. *Paratypes* will be deposited in the insect collections of the Utah Agricultural Experiment Station and duplicate material in other museums.

A DESKBOOK OF STYLE, by F. W. Beckman and Blair Converse, 1935, 4th Edition. Pp. 87, 5 x 7.5 inches, cardboard cover. Published by Collegiate Press, Inc. Price, 50 cents.

We call attention to this little style book as being very condensed and well organized. It is probably too brief for the average experienced writer but at its low price should be in the hands of the many graduate students on the threshold of a life of expository writing.

Perhaps the thing which endears it to us is that the first page starts off with the heading Clean Copy. Nine rules are given. The one which contributors to the Annals break most often is that which states, "All matter must be double or even triple-spaced." To the quotation we add: *This rule covers headings, footnotes, legends and bibliographies.*

We do not know what the wage is in Columbus but on the Atlantic seaboard, union compositors demand and receive 4 dollars an hour. In the middle west the wage is much less but in all printing establishments it is so high that copy which is confusing or difficult to read cannot be tolerated. The losses involved in slowing up such high-priced labor are charged back to the customer which for "dirty" copy coming to this office is a charge directly against the treasury of the Society.

We like such a frank book and recommend it to graduate students.—C. H. K.

APHIS SPECIES INFESTING RIBES

(Homoptera: Aphidae)[1]

MERLIN W. ALLEN AND GEORGE F. KNOWLTON[2]
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Logan, Utah

The following report deals with seven species of the aphid genus *Aphis* which feed upon currants and gooseberries. One species appears to be undescribed and is here described as new.

The writers[3] have found some difficulty in constructing a key which would consistently and easily separate the various species to their proper positions. Several of the species are very closely related and some question might exist as to whether all of the forms justify specific rank.

KEY TO ALATE FEMALES

A. Cornicles not exceeding 0.16 mm. in length.
  B. Cauda bearing fewer than five pairs of lateral hairs.
    C. Secondary sensoria present on antennal V.....**ribi-gillettei** n. sp.
    CC. Secondary sensoria usually absent on antennal V.....**ribiensis**
  BB. Cauda bearing five or more pairs of lateral hairs.....**ribis**
AA. Cornicles exceeding 0.16 mm. in length.
  B. Unguis exceeding 0.30 mm. in length.....**grossulariae**
  BB. Unguis rarely exceeding 0.30 mm. in length.
    C. Sensoria on antennal IV seldom exceeding four in number.....**sanborni**
    CC. Sensoria on antennal IV usually exceeding five in number.
      D. Secondary sensoria typically absent on antennal V.....**neomexicana**
      DD. Secondary sensoria typically present on antennal V.....**varians**

Aphis grossulariae Kaltenbach

(Figs. 1–7)

Alate vivipara: Body 1.94 to 2.15 mm. long; antennae dusky, 1.29 to 1.37 mm.; antennal III, 0.28 to 0.32 with 12 to 15 sensoria; IV, 0.2 to 0.24 with 7 to 8 sensoria; V, 0.17 to 0.2 with 1 to 3 sensoria; VI, 0.12 to 0.14 + 0.32 to 0.36; rostral IV + V, 0.14 to 0.15; hind tibiae 1.02 to 1.12; hind tarsi 0.1 to 0.12; cornicles 0.29 to 0.34, dusky; cauda 0.15 to 0.19 mm., dusky.

Apterous vivipara: Body 1.78 to 1.88 mm. long; antennae 1.14 to 1.18, pale; antennal III, 0.24 to 0.28, without sensoria; IV, 0.17 to 0.2; V, 0.14 to 0.16; VI, 0.12 to 0.13 + 0.26 to 0.3; rostrum attaining 3rd

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[1]Contribution from the Department of Entomology, Utah Agricultural Experiment Station.

[2]Research assistant and research associate professor of entomology, respectively.

[3]The writers are indebted to C. F. W. Muesebeck, P. W. Mason, T. H. Frison, E. O. Essig, M. A. Palmer, and E. M. Patch for the loan of material for study. Unless otherwise indicated, material was collected by G. F. Knowlton in Utah.

Authorized for publication.

coxae; hind tibiae 0.86 to 0.88; cornicles 0.34 to 0.41; cauda 0.19 to 0.22 mm., pale.

Collections: One identified slide was received from Professor E. O. Essig, collected upon gooseberry at Cambridge, England, June 19, 1936 (A. D. Imms).

Taxonomy: Aphis grossulariae differs from *A. neomexicana* in having longer unguis and body.

Aphis neomexicana Cockerell

(Figs. 8–14)

Alate vivipara: Body 1.59 to 1.86 mm. long; antennae 1.1 to 1.33 mm., dark; antennal III, 0.23 to 0.32 with 10 to 15 sensoria scattered over entire joint; IV, 0.19 to 0.27 with 5 to 9 sensoria; V, 0.17 to 0.22 rarely with 1 sensorium; VI, 0.11 to 0.14 + 0.24 to 0.28; rostral IV + V, 0.13 to 0.16; hind tibiae 0.88 to 1.1; hind tarsi 0.08 to 0.1; cornicles 0.24 to 0.32, dark; cauda 0.15, dusky.

Apterous vivipara: Antennae 0.9 to 0.98, pale; antennal III, 0.2 to 0.25, without sensoria; IV, 0.16 to 0.22; V, 0.15 to 0.2; VI, 0.1 to 0.12 + 0.2 to 0.22; cornicles 0.29 to 0.32; other characters as in alate vivipara. Some individuals are rather small.

Collections: Collected in Utah on *Ribes* sp. at Hooper and Plain City, June 3, 1935 (K.—C. F. Smith); Provo, Springville and Summit, June 10, 1935; and Taylor, June 11, 1935. Also 2 slides of Colorado specimens were lent by Professor M. A. Palmer, collected from *Ribes aurium*, May 25, 1914, at Fort Collins (L. C. Bragg) and from *R. cereum*, at Bellvue, July 4, 1933 (M. A. Palmer).

Taxonomy: Aphis neomexicana differs from *Aphis varians* Patch in averaging fewer sensoria on antennal III of alates, and typically possessing no sensoria on antennal V of alates.

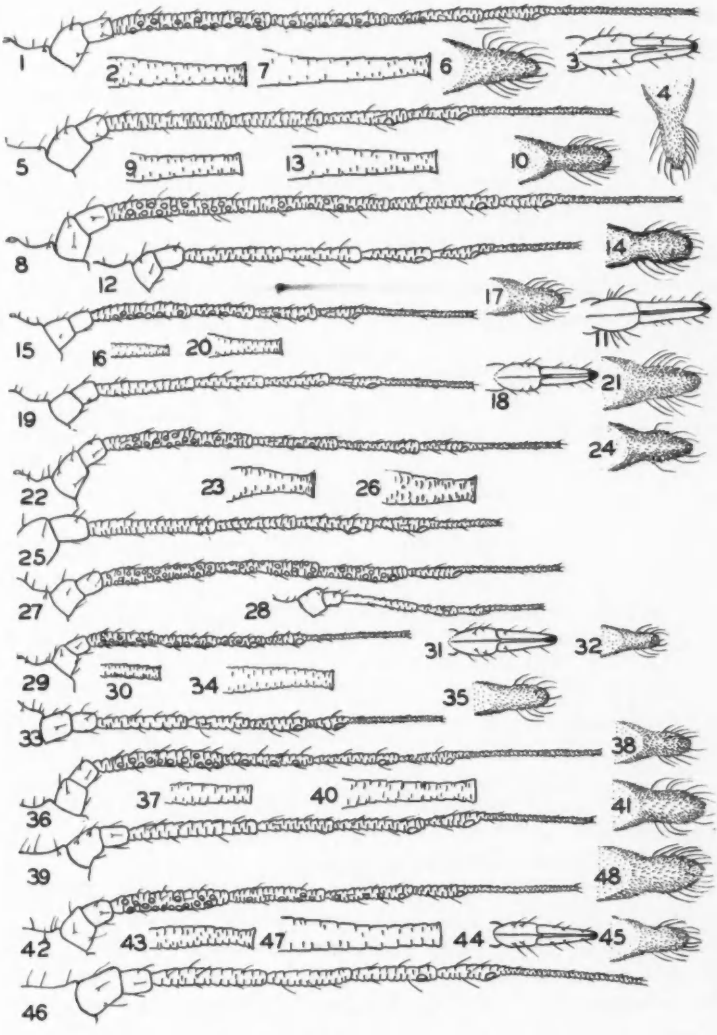
Aphis ribiensis Gillette and Palmer

(Figs. 22–28)

Alate vivipara: Color greenish black; body 1.35 to 1.78 mm. long; antennae 0.9 to 0.96, blackish entire length; antennal III, 0.2 to 0.25 with 10 to 18 sensoria; IV, 0.14 to 0.18 with 4 to 6 sensoria; V, 0.14 to 0.15, without sensoria; VI, 0.1 to 0.12 + 0.19 to 0.26; rostral IV + V, 0.1; hind tibiae 0.61 to 0.79; hind tarsi, 0.08 to 0.1; cornicles dusky, 0.12 to 0.14; cauda 0.16, dusky, with 2 to 4 lateral hairs.

Apterous vivipara: Antennal III, 0.18 to 0.23; IV, 0.12 to 0.16; V, 0.12 to 0.16; VI, 0.1 + 0.18 to 0.24; hind tibiae, 0.67; cornicles, 0.15 to 0.21, pale; cauda, 0.14, pale.

Alate male: Body 1 to 1.12 mm. long; antennal III, 0.24 to 0.26 with 22 to 29 sensoria; IV, 0.18 to 0.22 with 16 to 20 sensoria; V, 0.16 to 0.2



Aphis grossulariae Kalt. Alate, 1–4; aptera, 5–7. *A. neomexicana* Ckll. Alate, 8–11; aptera, 12–14. *A. ribis* Sanborn. Alate, 15–18; aptera, 19–21. *A. ribiensis* G. & P. Alate, 22–24; apterous vivipara, 25–26; alate male, 27; apterous ovipara, 28. *A. ribi-gillettei* n. sp. Alate, 29–32; aptera, 33–35. *A. sanborni* Patch. Alate, 36–38; aptera, 39–41. *A. varians* Patch. Alate, 42–45; aptera, 46–48.

with 8 to 12 sensoria; VI, 0.1 to 0.12 + 0.18 to 0.3, base with 0 to 3 secondary sensoria; hind tibiae 0.75; cornicles 0.11 mm. long, pale.

Apterous ovipara: Body 1.02 mm. long; antennae, 0.47, pale; antennal III, 0.12; IV, 0.06; V, 0.06 + 0.1; hind tibiae, 0.36 with 11 to 23 sensoria; cornicles 0.1, pale.

Collections: Alate vivipara, alate males and apterous ovipara on currant, *Ribes* sp. in Utah at Willard, October 11, 1937; apterous vivipara on *Ribes* sp. at West Point, June 11, 1935; Richmond, July 24, 1936 (C. F. Smith and F. C. Harmston).

Taxonomy: Aphis ribiensis differs from *Aphis ribi-gillettei* K. and A. in larger size, fewer hairs on cauda, and no sensoria on antennal V of alate. Specimens from Utah are slightly smaller than Colorado material.

Aphis ribi-gillettei K. and A., n. sp.

(Figs. 29–35)

Alate vivipara: Color pale green; body 0.82 to 1.12 mm. long; antennae, 0.71 to 0.94 mm. long, dusky throughout; antennal III, 0.13 to 0.19 mm., with 9 to 17 sensoria; IV, 0.11 to 0.14, with 4 to 8 sensoria; V, 0.1 to 0.13, usually with 2 sensoria, rarely 0, 1 or 3; VI, 0.07 to 0.08 + 0.2 to 0.28; rostral IV + V, 0.1 to 0.11; hind tibiae 0.51 to 0.71; hind tarsi, 0.06 to 0.07; cornicles, 0.12 to 0.16, pale, imbricated entire length; cauda, 0.10 to 0.12, dusky.

Apterous vivipara: Color light green; body 0.92 to 1.2 mm. long; antennae 0.71 to 0.8, pale; antennal III, 0.15 to 0.18, without sensoria; IV, 0.1 to 0.13; V, 0.1 to 0.12; VI, 0.07 to 0.08 + 0.18 to 0.26; rostral IV + V, 0.12; hind tibiae, 0.56 to 0.69; hind tarsi, 0.08; cornicles, 0.17 to 0.22, imbricated; cauda, 0.13 to 0.16 mm. long.

Collections: Collected from within curled terminal leaves of currant, usually yellow currant, and gooseberry, *Ribes* species, in Utah at Brigham, Farmington, Harrisville, Hooper, Kanesville, Ogden, and Willard, July 6 to 8, 1933; Granger, July 15, 1932; Salt Lake City and Taylorsville, September 8, 1937 (K.—F. C. Harmston); Riverheights.

Taxonomy: This species which the writers are designating as the Utah currant aphid, runs to *Aphis ribiensis* G. & P. in Gillette and Palmer's key (Ann. Ent. Soc. of America 15: 375) from which it differs in having sensoria on antennal V; as well as possessing shorter antennal III, body, and hind tibiae.

Aphis ribis Sanborn

(Figs. 15–21)

Alate vivipara: Body 1.18 to 1.23 mm. long; antennae 0.88 to 1.01, dusky; antennal III, 0.21 to 0.22 with 6 to 8 sensoria; IV, 0.13 to 0.17 with 2 to 5 sensoria; V, 0.13 to 0.16 with 0 to 2 sensoria; VI, 0.09 to

0.1 + 0.2 to 0.22; rostral IV + V, 0.12; rostrum reaching second coxae; hind tibiae 0.67 to 0.73; hind tarsi 0.08; cornicles 0.1 to 0.13; cauda, 0.12 to 0.16, pale.

Apterous vivipara: Body 1.31 to 1.33 mm. long; antennae, 0.73 to 0.96, pale; antennal III, 0.18 to 0.24; IV, 0.12 to 0.16; V, 0.11 to 0.14; VI, 0.1 + 0.18; rostral IV + V, 0.13; hind tibiae 0.63 to 0.67; hind tarsi 0.1; cornicles, 0.13 to 0.14, pale; cauda, 0.16 to 0.17.

Alate male: Body 1.49 to 1.53 mm. long; antennae, 0.97 to 0.98, dark; antennal III, 0.21 to 0.24 with 22 to 28 sensoria; IV, 0.14 to 0.16 with 10 to 14 sensoria; V, 0.13 to 0.14 with 5 to 7 sensoria; VI, (? broken); rostral IV + V, 0.1; hind tibiae, 0.73 to 0.75; hind tarsi 0.1 to 0.11; cornicles 0.12 to 0.14, pale; cauda, 0.12 to 0.14.

Collections: On *Ribes gracile*, Columbia, Missouri (Hayhurst). One identified slide was borrowed through the Bureau of Entomology and Plant Quarantine, Division of Insect Identification, from the U. S. National Museum, Washington, D. C.

Taxonomy: Aphis ribis Sanborn differs from other *Aphis* species found on *Ribes* in having fewer sensoria on antennal III of alate.

Aphis sanborni Patch

(Figs. 36–41)

Alate vivipara: Body 1 to 1.25 mm. long; antennae 0.84 to 1.1 mm., dark; antennal III, 0.22 to 0.28 with 7 to 13 sensoria; IV, 0.18 to 0.22 with 2 to 4 sensoria; V, 0.15 to 0.18 with 0 to 1 sensorium; VI, 0.08 to 0.12 + 0.21 to 0.23 mm.; rostral IV + V, 0.1 to 0.12; hind tibiae 0.84 to 0.91; hind tarsi 0.08 to 0.09; cornicles pale, 0.18 to 0.2; cauda 0.14 to 0.15, pale.

Apterous vivipara: Body 1.33 to 1.55 mm. long; antennae 0.98 to 1.06; antennal III, 0.22 to 0.24; IV, 0.14 to 0.19; V, 0.16 to 0.18; VI, 0.1 to 0.12 + 0.22 to 0.24; hind tarsi 0.1; cornicles 0.2 to 0.28, white; cauda 0.16 to 0.21, pale.

Collections: Three identified slides were examined from T. H. Frison, Rock Island, Ill.; May 16, 1931 (Ross and Mohr.); two from M. A. Palmer, gooseberry, Rock Island, Ill. June 3, 1930 (Frison and Ross); also Clarks Mts., Pa., on gooseberry (J. O. Pepper).

Taxonomy: Aphis sanborni differs from *A. variens* in having fewer sensoria on antennal III of alate and shorter cornicles; it differs from *A. neomexicana* in having shorter cornicles.

Aphis varians Patch

(Figs. 42–48)

Alate vivipara: Color blackish green; body, 1.23 to 1.74 mm. long; antennae, 1.02 to 1.2 mm. long, black entire length; antennal III, 0.22 to 0.28 with 12 to 22 sensoria; IV, 0.16 to 0.22 with 5 to 9 sensoria; V,

0.16 to 0.2 with 0 to 2 sensoria (occasionally 3 or 4); VI, 0.1 to 0.12 + 0.24 to 0.3; rostrum attaining third coxae; rostral IV + V, 0.12 to 0.13; hind tibiae 0.74 to 0.92; hind tarsi 0.08 to 0.11; cornicles 0.2 to 0.27, dusky; cauda, 0.12 to 0.16, dusky.

Apterous vivipara: Body 1.33 to 1.84 mm. long; antennae 0.92 to 1.23, pale; antennal III, 0.2 to 0.28; IV, 0.18 to 0.22; V, 0.12; hind tibiae 0.82 to 0.92; hind tarsi 0.09 to 0.11; cornicles, 0.26 to 0.32, pale; cauda 0.16 to 0.2, pale.

Collections: In curled leaves of *Ribes* species, usually black currant, collected in Utah at Blacksmith Fork Canyon, June 16, 1935 (T. O. Thatcher); Bluffdale; Brigham (K.—C. F. Smith); Cedar City; Centerville; Farmington; Holliday; Hooper (K.—Smith); Kanesville (K.—Smith); Logan; Mill Creek, June 18, 1930; New Castle, June 15, 1935; Parowan; Penrose; Perry, July 2, 1935; Plain City (K.—Smith); Provo; Salt Lake City; Snowville, June 17, 1931; Springville; Summit; Syracuse; Taylorville. Collected in Idaho on black currant at Arimo and St. Anthony, June 13, 1936; Rexburg, June 21, 1935 (C. F. Smith). Also Rocky Mountain National Park, Colorado, August 23, 1935; and at Cherryville, Oregon, May 18, 1936 (Mrs. A. L. Candee).

Taxonomy: Very near to *Aphis neomexicana*, but averaging more sensoria on antennals III and V of alate.

A FIRST GERMAN COURSE FOR SCIENCE STUDENTS, by H. G. FIEDLER and F. E. SANDBACH. Pp. 110, 3rd Ed. Price $1.25.

A SCIENTIFIC GERMAN READER by H. Z. KIP. Pp. 462, 32 figs. Price $1.20.

A GERMAN READER FOR BIOLOGY STUDENTS by H. G. FIEDLER and G. R. DE BEER with vocabulary by HERMA E. FIEDLER. 1933. Pp. 92, 5.5 x 8.75 inches. Price $1.25.

All three published by OXFORD UNIVERSITY PRESS, 114 Fifth Ave., New York, N. Y.

We cite the three works above as a possible partial solution of clearing the way for an economic-minded student, in any of the branches of applied biology, to become sufficiently conversant with the German language to secure a Ph. D. rating. As these works are sponsored by the Oxford University Press the same problem of "working off" foreign languages appears to have arisen in England. This need has come with the rise of the many city universities such as those of London, Birmingham, Leads, Manchester, etc., which go into the elaborate training of engineers, medical men and other leaders in the highest non-political level of English society.

We have at hand the third of the volumes cited. Its excellence lies in its vocabulary which occupies almost half of the book, pages 55 to 92. The authors assumed a knowledge on the part of the student of grammar as is given in the volume by Fiedler and Sandbach. As our secretary does our spelling and punctuation for us we are in no position to remark on means of learning a language. We merely call attention to these volumes which are from a source we have trusted for sound contributions to various world literatures.—C. H. K.

BIOLOGICAL NOTES ON THE EGG PARASITES OF MALACOSOMA DISSTRIA Hbn.[1,2,3,4]

A. C. Hodson
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University of Minnesota,
University Farm, Saint Paul, Minn.

Observations have been made on egg parasitism in the forest tent caterpillar, *Malacosoma disstria* Hb., as a part of a comprehensive ecological study of the species. Five species of Hymenoptera have been reared from egg masses collected in several localities in northern Minnesota. The following species have emerged from the various samples of egg masses: *Ablerus clisiocampae* Ashm., *Trichogramma evanescens* Westw., *Oöencyrtus clisiocampae* Ashm., *Tetrastichus sylvaticus* Gahan, and *Telenomus clisiocampae* Ashm. *A. clisiocampae* and *T. evanescens* were each found in only one sample of eggs, while the other three species were present in nearly all of the collections which have been studied.

In previous papers on the egg parasites of *Malacosoma americana*, all of the parasites except *T. sylvaticus* and *T. evanescens* have been reported. Williams (1916) and Porter (1917) found *Tetrastichus malacosomae* Gir. to be the most abundant species in the eggs of the eastern tent caterpillar. Both species of *Tetrastichus* have been reared from eggs of *M. americana* which were collected in northern Minnesota during the summer of 1937. *T. sylvaticus* may have been confused with *T. malacosomae* previously because it has been described just recently by Gahan (1937).

An analysis of rearing records shows clearly that these species are not very important natural enemies of *M. disstria*. Fifty egg masses were selected at random from collections taken in six different localities in northern Minnesota. These eggs were set up in emergence boxes to determine the general

[1]The author is indebted to A. B. Gahan, of the Bureau of Entomology, for the identification of the parasite species.

[2]Egg masses were obtained through the co-operation of the Forestry Division of the State of Minnesota and the Federal Forest Service.

[3]Assistance in the preparation of these materials was furnished by the personnel of Works Progress Administration Official Project No. 165–71–6999–3–400.

[4]Paper No. 1641 of the Scientific Journal Series of the Minnesota Agricultural Experiment Station, St. Paul.

distribution and abundance of the parasites. The relative abundance of the three most common species of parasites and the total number of parasites per egg mass for the years 1936 and 1937 are presented in Table I. The localities are indicated by the section, township, and range numbers.

The data summarized in Table I show clearly that the three most common parasites are found rather uniformly throughout the area infested by the host. The only very significant difference in the 1936 and 1937 populations is the increase in the importance of *T. sylvaticus*. The average number of parasites per egg mass is about the same for both years, even

TABLE I

PARASITE EMERGENCE FROM EGGS COLLECTED IN SEVERAL MINNESOTA LOCALITIES DURING 1936 AND 1937

Tetrastichus sylvaticus, Ooencyrtus clisiocampae and Telenomus clisiocampae

LOCATION	PERCENTAGE OF TOTAL NUMBER OF PARASITES						NUMBER OF PARASITES PER EGG MASS	
	Tetrastichus		*Ooencyrtus*		*Telenomus*			
	1936	*1937*	*1936*	*1937*	*1936*	*1937*	*1936*	*1937*
20–148–30W	0.0	17.0	36.0	58.5	64.0	24.5	2.1	1.5
30– 57–11W	15.0	14.0	51.6	54.1	33.4	31.9	6.9	8.8
29– 65– 2W	7.9	35.8	53.5	44.5	38.6	19.7	8.4	8.6
5– 61–15W	0.8	21.0	47.2	48.4	52.0	30.6	2.5	3.5
24–144–36W	4.8	76.3	61.4	7.9	33.8	15.8	3.3	0.7
31– 62–11W	3.8	50.7	56.4	39.4	39.8	9.9	1.5	3.8
Average	5.4	35.8	51.0	42.1	43.6	22.1	4.1	4.5

though there is some greater annual variation in specific localities. The heaviest parasitism of the host eggs was found in the eastern part of the infested area where the outbreak had been in progress for the longest time.

The most interesting and puzzling problem made evident by this investigation is the fact that in many samples nearly all of the egg masses were attacked by parasites, and yet the average egg parasitism was uniformly low. Table II shows the relation between these two values in fourteen localities. The data were obtained from samples of from 50 to 60 egg masses.

The figures show that there was a relatively high percentage of the egg masses attacked, an average of 38.5 per cent in 1936 and 73.1 per cent in 1937; at the same time the percentage of

eggs parasitized was 2.3 and 7.2 respectively. It is evident that there was a definite increase in the amount of parasitism in 1937. The significant fact seems to be that there was a much greater absolute increase in the number of masses than in the eggs attacked. The relative abundance of parasites in the 1936 collection of egg masses can be seen from the following data: In one hundred egg masses selected at random 29.2 per cent had one parasite per mass; 20 per cent, two parasites; 15.4 per cent, three parasites; 7.7 per cent, four parasites; and

TABLE II

THE RELATION BETWEEN THE NUMBER OF EGG MASSES ATTACKED AND THE PERCENTAGE OF EGGS PARASITIZED

LOCATION	PERCENTAGE OF EGG MASSES WITH PARASITES		PERCENTAGE OF TOTAL EGGS PARASITIZED	
	1936	*1937*	*1936*	*1937*
34–148–30	28.3	46.0	1.7	2.6
20–148–30	26.6	46.0	2.3	2.5
23– 59–26	50.0	86.0	2.3	6.9
5–150–28	13.3	57.1	0.3	3.4
19– 65–13	53.3	88.0	2.4	10.0
30– 57–11	56.6	88.0	4.1	8.4
25– 62– 2	45.0	68.0	4.7	5.7
29– 65– 2	65.0	98.0	4.2	15.5
31– 62–11	21.6	96.0	0.9	12.7
32– 59– 4	35.7	100.0	2.0	11.2
18– 63–16	26.6	86.0	1.3	9.5
34– 69–21	58.3	76.0	3.2	7.0
9–147–35	30.0	40.0	0.9	3.1
5– 61–15	28.3	48.0	1.1	2.4
Average	38.5	73.1	2.3	7.2

the remainder consisted of smaller percentages of larger numbers per mass. Less than four parasites emerged from 64.6 per cent of the masses, although in two cases 50 per cent of the eggs were parasitized. The problem is complicated further by the presence of all combinations of any two of the three common species in one egg mass.

There appeared to be several possible explanations for this low rate of parasitism under the conditions of a favorable host supply and a general distribution of the parasites. A high rate of parasite mortality might be responsible. The life cycles of host and parasite might not be well-synchronized. The parasites could have more than one generation a year, and

require an additional host. The egg-laying habits of the parasite might make complete oviposition in one mass unlikely. The eggs of the host might present some physical characteristics which would make oviposition difficult. Finally, the parasites might have difficulty in finding the eggs.

The possibility of a high parasite mortality rate being the limiting factor may be disregarded. Numerous microscopic examinations of egg masses have revealed a very low percentage of dead parasites, and rearing records show a high rate of successful emergence.

The question of the agreement between the life cycles of the host and parasites may next be considered. Egg masses were collected in the field at four-day intervals after the first ones were observed. The subsequent parasite emergence records showed that the eggs were attacked at the beginning of the oviposition period. There was no increase in the number of eggs parasitized after twelve days. The host eggs are laid during the first two weeks in July. Insectary emergence records indicated that presence of the three common parasite species from early June until about the middle of July. These observations demonstrate the parasites are active at the time when the newly laid host eggs are present in the forest.

It seems improbable that the efficiency of the parasites is conditioned by a necessity for an additional host. The embryonic development of the host and the larval development of the parasites are both completed about three weeks after the host eggs have been deposited. The parasite larvae remain in a dormant condition until the following spring. Only *Tetrastichus* adults emerge as soon as two months after the period of moth flight. Only an occasional individual of this species emerges before spring under natural conditions. The larvae of *Oöencyrtus* enter a diapause which does not require an exposure to low temperatures to be broken. The adults of *Telenomus* do not develop until the larvae have remained for at least a month at temperatures below 15° C.

The parasites usually emerge from the egg masses long after the hatching of the host larvae which takes place about the middle of May. The average time required for parasite emergence at 25° C. after a six-month dormant period at 2° C. is as follows: *T. sylvaticus*, 14.3 days; *O. clisiocampae*, 33.5 days; and *T. clisiocampae*, 37.8 days. Under the same conditions the host larvae hatch in 4.5 days. Under natural conditions

the difference between the time of the appearance of the host larvae and the parasites is even greater because the larvae leave the eggs at temperatures as low as 10° C., and only a small percentage of the parasites will emerge at 15° C.

The longevity of the parasite adults is important in this discussion. Table III shows the length of life of three species at different temperatures.

In this experiment the parasites were fed moistened raisins. All three species can live for two weeks or more at temperatures such as those which prevail during early summer in northern Minnesota. It has been mentioned that *Tetrastichus* emerges earlier than the other species. Table III shows that it is longer

TABLE III

PARASITE LONGEVITY IN DAYS AT FOUR TEMPERATURES

SPECIES	10° C.		15° C.		20° C.		25° C.	
	Fed	Unfed	Fed	Unfed	Fed	Unfed	Fed	Unfed
Tetrastichus	116.0	.....	41.4	.....	37.2	.....	38.2	.....
Ooencyrtus	7.5	9.2	23.0	6.3	19.2	3.7	11.8	1.4
Telenomus	5.5	6.0	14.6	4.5	15.5	4.0	13.0	.....

lived than the other species and is more resistant to low temperatures. These facts make it evident that the parasites do not require additional host species in order to exist.

No observations have been made with regard to the process of oviposition of any of these species. Laboratory specimens have mated readily but no egg-laying has been watched. Maple (1937) has reported on the habits of oviposition of *O. johnsoni*. He states that this species lays only a few eggs each day because of the long time required for the deposition of a single egg. A similar condition may cause the parasites in this study to leave the masses after laying few eggs.

It is possible that the physical structure of the egg mass may be responsible for the low percentage of parasitized eggs. In nearly all of the masses which had been attacked the parasites were found in the marginal rows of eggs. The following data from 52 egg masses show the distribution of parasites by egg rows: Outside row, 49.7 per cent; second row, 33.0 per cent;

third row, 8.9 per cent; fourth row, 3.4 per cent; fifth row, 3.0 per cent; and the sixth row, 2.0 per cent. The average number of rows of eggs per egg mass was 9.6. These marginal eggs may be more easily punctured because they are often only partly protected by the frothy substance with which the egg masses are covered. It has also been observed that poorly constructed masses which are not completely smeared with the protective coats are more heavily parasitized. The eggs of *M. americana* which had been laid on the sides of the lower stems of wild cherry showed a like distribution of parasites. In this case there were marginal eggs completely around the masses and yet the parasites were found at the upper and lower ends of these oval masses. It is possible that there is a preference for the marginal eggs, and that a rather small parasite population makes it unnecessary for the females to go beyond the outer rows to find host material.

Evidence is offered to show that the three most common egg parasites of *M. disstria* are well adapted to the life cycle of the host and are widely distributed in the area infested by the host. It may be concluded that the low rate of egg parasitism is due more to factors associated with oviposition and egg mass construction than it is to other suggested possible influences.

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NEW DISEASES OF TERMITES CAUSED BY BACTERIA

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During the past few years in the course of large-scale laboratory rearing of *Zootermopsis angusticollis* Hagen, various diseases have repeatedly been observed to kill individuals or groups of termites. Occasionally these have taken on the proportion of an epizoötic, but more frequently they have shown up sporadically in the death of one or a few individuals of a group. The mortality resulting from these diseases is a serious factor in the experiments being carried on upon the problem of caste differentiation in *Zootermopsis* by Dr. S. F. Light of the Zoology Department of the University of California. It was with the purpose of learning more concerning the causes of this mortality, that the present study was undertaken. From the practical viewpoint of laboratory control of the disease and from the biological viewpoint the problem is of considerable interest. Apparently the diseases studied are as yet undescribed for any termite.

Aside from certain fungus diseases, the two bacterial diseases which are treated in this paper were the most noticeable causes of mortality in the laboratory stock. That they were singled out for study is due to the fact they were observed repeatedly and could be identified by their striking effect upon the termite. Undoubtedly with further work more disease-producing bacteria will be isolated from *Zootermopsis*.

SYMPTOMS

Of these two diseases, the more common and conspicuous was one which causes the termite when dead to turn various shades of red. The discoloration invades all parts of the hemocoele, sometimes causing the whole body to appear a brilliant red. The change in color usually appears first in the head and becomes most intense in that region; the legs also often become more deeply colored than the thorax or abdomen. The red pigment has never been definitely observed to appear in a termite before death. Although the specific disease then cannot be recognized, the sick and dying termites are easily distinguished by their general lethargy, cessation of feeding, leaving of the group, and finally by a loss of motion. An individual in the last stages is often

found on its back and remains thus feebly moving its antennae until death. Generally the discoloration appears after termites have been dead for approximately a day. The reason why a diseased termite tends to leave the group is not known. It is probably not driven out by its fellows, for individuals which have been accidently injured so that they extrude a little body fluid have often been observed to be attacked by their cannibalistic relatives who proceed leisurely to devour various parts of the body, sometimes as much as the entire abdomen, apparently without the victim taking especial notice or alarm. The answer may lie in the fact that the diseased insect becomes hypersensitive to contact, and hence moves away from the group. Diseased termites have several times been observed to jerk spasmodically for a period of several seconds, apparently an effect of the disease on the nervous system. If a diseased termite is not eaten immediately after death, the members of the colony exhibit an interesting social behavior by walling off the corpse from the rest of the colony with fecal pellets and bits of wood plastered together. Preliminary work placed the bacterium causing these symptoms in the genus *Serratia* (Bizio) Bergey et al.

The second disease is both less common and less striking than the one just mentioned. It is characterized in its early stages by the same reactions on the part of the termite, such as lethargy, cessation of feeding, etc. In this case, however, the termite turns black eighteen to thirty-six hours after death. Furthermore, the color is localized mainly in the head and appendages. The color of the head is especially noticeable, often being quite black. The thorax and abdomen are rarely affected by a change in color except that caused by general disintegration. The discoloration in this case is presumably due to the effect of bacterial end products on the exoskeleton, and not to a pigment produced by the bacteria, as in the case of the red-pigment-forming bacterium. This will be discussed more fully in a description of the bacteria. Preliminary work placed the bacterium causing this disease in the genus *Bacterium*.

PATHOGENICITY

Actual experimental work began with the preparation of agar plate streaks from various diseased termites. In each case several different colonies of bacteria developed on the plates. This of necessity led to the suppositions that we were dealing entirely with saprophytic species which merely caused the changes observed in termites dying a natural death, or that one bacterial species was the pathogen and another, acting as a saprophyte, was producing the observed changes.

In order to determine which of the bacteria, if any, was pathogenic, two types of tests were used: namely, feeding experiments and inoculation experiments.

FEEDING EXPERIMENTS

In all cases termites were kept in one-ounce ointment jars which are used in routine experimental work. The termites were fed by

saturating No. 1 filter paper, cut to the size of the jar, with thick suspensions of pure cultures of the bacterial species being tested. The preliminary experiments in which characteristic symptoms appeared made possible the isolation for intensive tests of the two species of bacteria herein discussed. The others were eliminated by various tests for pathogenicity. These included a yellow pigment producing Gram positive coccus resembling *Sarcina*, and a Gram negative rod, producing a green fluorescent pigment resembling *Pseudomonas*. Neither of these was pathogenic. Five groups of ten termites each were fed the bacterial-impregnated filter paper for a two-week period. New filter papers impregnated with fresh suspensions were introduced on the fifth and tenth days. Controls involved feeding filter paper moistened with distilled water.

A general observation has been that these diseases occur only in a very moist environment. That this in itself is not a cause of mortality is evidenced by the fact that these termites thrive normally in a saturated, or near saturated, atmosphere as well as by the fact that the controls, themselves kept equally moist, continued to thrive. In Table I is given the mortality, at the end of two weeks, caused by each disease.

TABLE I

Disease	Number of Termites	Number Dead	Per Cent Mortality
Serratia	50	25	50
Bacterium	50	11	22
Control	50	0	0

Throughout the period of feeding, the rate of mortality was approximately the same, perhaps increasing slightly after each new feeding. That both diseases may be transmitted by feeding indicates that this may be the means of transferring the disease in laboratory groups since the healthy termites tend to eat sick and dead individuals as well as fecal material and hence may contract the disease in this manner.

The per cent mortality for both of these diseases falls between extremes reported by various authors or other insect diseases. Calculations from Glaser's tables (1918) show approximately 83 per cent mortality to larvae of the gipsy moth fed *Streptococcus disparis*. He also shows (1924) a 50 per cent mortality for house flies fed *Staphylococcus muscae*. This is similar to our results with *Serratia* and is stated to produce sporadic control. Mortality as low as fifteen per cent by feeding *Bacillus sphingidis* to hornworms is shown by White's figures (1923). This is lower than we have found for the *Bacterium* disease. These figures are based on fifty-four larvae fed bacteria from animals dead less than one day. After this period little or no mortality results. However, White shows nearly one hundred per cent mortality for inoculation experiments with fresh material.

INOCULATION EXPERIMENTS

Inoculation experiments tend to bear out the general results shown for feeding experiments except that they give approximately a two to threefold increase in mortality and cause death much more quickly. Inoculations were made by puncturing the exoskeleton and introducing the bacilli into the hemolymph. Small, sharpened, hypodermic needles of 26 gauge were used to introduce the bacilli after dipping in a suspension similar to that used in the feeding experiments.

Inoculation of the bacteria as shown in Table II gave much greater mortality than introduction by ingestion, but a fairly proportionate mortality increase for each disease. Mortality also occurs much more rapidly; all deaths represented in Table II, with the exception of one termite, occurred within three days or less after inoculation. Red coloration has been observed developing in the dead termite eighteen hours after inoculation. Inoculations were made in the pleural region of the abdomen and through the head capsule. In no case did this treatment appear to harm the controls.

TABLE II

Disease	Number of Termites Inoculated	Number of Termites Dead 3 Days After Inoculation	Per Cent Mortality
ABDOMINAL INOCULATION			
Serratia	10	9	90
Bacterium	10	6	60
Control	10	0	0
HEAD INOCULATION			
Serratia	5	5	100
Bacterium	5	3	60
Control	5	0	0

The bacteria causing both diseases were recovered in pure culture from the body fluid of dying termites, some of which had been fed bacteria for several days and some of which had been inoculated with the bacteria by the puncture method. In order to eliminate the occurrence of contamination from the body surface when hemolymph was removed, the termites were first sterilized by immersing them in a mixture of hexyresorcinol (1/1000) and phenol (1/20) for a period of two minutes. Plating tests of normal termites, both of the hemolymph and of the body surface, sterilized in this manner, failed to show any bacteria present. Even termites which had been fed on contaminated filter paper for two weeks, and some which had been dipped in thick suspensions of both bacteria, were sterilized externally by this method. Termites may come through this treatment alive and appear quite normal after a period of time.

Metalnikov (1926) has reported that many saprophytic bacteria are quite pathogenic to insects. Two, which were considered to be fairly closely related to those with which we were dealing, were tested by the puncture method of inoculation. On fifteen termites a stock culture of *Serratia marcescens*, the cause of red bread, gave a 60 per cent mortality in two days with no change thereafter. A stock culture of *Aerobacter aerogenes*, commonly present in water, caused 100 per cent mortality in two days.

The question of immunity in insects, studied by Paillot (1933), Metalnikov (1926), and others, is of especial interest in our results. The question was: Have the termites which have been fed bacteria two weeks and are still apparently healthy, acquired an immunity or do they resist the disease for some other reason? Fifteen termites, which had been fed *Bacterium* and fifteen which had been fed *Serratia* for two weeks, were inoculated with pure cultures by puncturing. After four days *Bacterium* inoculation gave 93 per cent mortality and *Serratia* 100 per cent mortality, indicating that immunity to large doses is not acquired by feeding. However, immunity to small doses of the bacteria, such as the amount liable to be entering through the gut, may possibly be acquired. Further study is necessary on this point. In general, however, it would seem that in nature, resistance aside from genetic changes would not be developed sufficiently to withstand infection from heavy doses of a pathogen.

DESCRIPTION OF THE ORGANISMS

Our preliminary work indicated that the red-pigment-forming Gram negative rod bore strong resemblances to *Serratia marcescens* (Bizio) Bergey et al. The non-pigment-forming Gram negative rod seemed to belong to the coli-aerogenes group. However, it was necessary to carry out the usual diagnostic tests to determine whether the organisms were identical to any previously described species. Furthermore, we thought it would be interesting from the standpoint of bacterial taxonomy to use the scheme of classification proposed by Kluyver and van Niel (1936) in contrast to the more universally used schemes of Bergey (1934), Topley and Wilson (1936), or Lehman and Neumann (1927). The Kluyver-van Neil (KvN) system outlines a scheme synthesized from previously proposed systems in which the authors believe they have incorporated the best features and avoided many of the fallacies. Briefly, it is a scheme which defines genera on the basis of catabolic type correlated with certain morphological characteristics such as cell shape, type of flagellation, and presence or absence of spore formation.

Using this system as a guide we carried out the various diagnostic tests on the two bacteria studied.

1. Red-Pigment-Forming-Rod

Principal Morphological Characteristics.—Small, Gram negative rod. Actively motile with peritrichate flagella. Endospores not present.

Catabolic Type.—Grows readily on ordinary peptone containing culture media under aerobic conditions. Facultative in respect to

free O_2, growing readily under atmosphere of CO_2 on glucose-containing media, less readily in plain nutrient broth without glucose. Most of the carbohydrates fermented with production of acid. Slight visible gas production (one or two bubbles in fermentation vial). Voges-Proskauer positive. Methyl red negative.

Consideration of these characters places the bacterium in the genus *Aerobacter* according to the system of Kluyver and van Niel, or in *Serratia* according to Bergey's System. Since more than enough synonyms already exist for this genus we do not feel justified in introducing another and adding to the confusion already prevalent. However, we do hope that the attention of others will be directed toward the Kluyver-van Niel system which we feel to be sound..

Ancillary criteria for species differentiation may be outlined as follows:

Special Morphological Criteria.—Somewhat variable in length. Rods usually occur singly. Capsule production not noted. Intracellular structure not visible.

Colony Morphology.—Plain agar (25 C-4 d)—Circular, smooth, entire edge slightly raised opaque. No phase variation observed, but both pigmented and non-pigmented colonies developed.

Gelatin plate—rapid and complete liquefaction.

Growth Characteristics.—Agar stroke: abundant growth; filiform; dull; pink to red or reddish purple pigment, nondiffusible; decided putrid odor; butyrous consistency.

Nutrient broth: ring of red pigment developes on surface; strong clouding of medium; intensely pigmented throughout (48 hrs. 25°C.).

Gelatin stab: (48 hrs. 25°C.). Growth best at top; line of puncture filiform; crateriform liquefaction begins in 24 hrs.; growth pigmented; pigment nondiffusible.

Potato: Pigment production no more intense than on plain agar.

Metabolic Activities.—Acid production (gas production slight or missing) from arabinose, xylose, glucose, fructose, galactose, mannitol, maltose, raffinose, inulin, dextrin, salicin.

No acid from lactose.

Starch not hydrolysed.

Gelatin: liquefied rapidly, complete liquefaction at 25° C. in about four days.

Milk: coagulated, not completely liquefied.

NH_3: positive.

H_2S: slight positive.

Catalase: positive.

Nitrates: reduced to nitrites but not to N_2 gas.

Methylene blue: complete reduction in 24 hours.

Litmus: decolorized.

Citrate: positive with pigment formation.

Uric acid: negative.

Horse red blood cells not hemolyzed.

Pigment Production.—Very rapid and intense. Varying in color and intensity with environmental conditions: Pink on plain agar at 37° C. in 24 hrs., deeper red at room temperature in 48 hrs., reddish

purple on glucose agar. Non-pigmented colonies on streak plates are unstable variants reverting to pigmented form in 48 hrs. Pigment soluble in alcohol, chloroform, acetone, but not soluble in water or ether. Pigment does not develop under anaerobic conditions.

Temperature Relations.

10° C.: fairly good growth in 5 days. 25° C.: good growth in 48 hours. 37° C.: abundant growth in 24 hours. 50° C.: poor growth in 24 hours.	Optimum temperature about 30° C.

A comparison of the results of these diagnostic tests for the red-pigment-forming bacterium was made with results of diagnostic tests on the species *Serratia marcescens* as used by Bergey (1934) or *Chromobacterium prodigiosum* as used by Topley and Wilson (1936) or *Bacterium prodigiosum* as used by Lehman and Neumann (1927). The essential differences are but slight, the red-pigment-forming rod described not differing from the descriptions of the type species more than the type species descriptions themselves differ from each other. We would conclude, therefore, that this bacterium is but another strain on this species. This strain is apparently pathogenic to termites under laboratory conditions—the disease has not been noticed among termites in their natural environments. Knowing the liability of certain bacterial characteristics, it would not be apropos to assign a new species name to this bacterium, either on the basis of its pathogenicity or certain minor cultural differences.

A word might be said in regard to other pathogenic species of this genus. A red-pigment-forming rod was reported as being pathogenic to the lizard (Duran-Reynals and Clausen, 1937). Although correctly named according to the system of Bergey, it perhaps bears closer relationships to members of the genus *Alcaligenes* or *Pseudomonas* since it is an obligate aerobic, small Gram negative, motile rod. If the type of flagellation were stated, it could be assigned to either one of these two genera, according to the system of Kluyver and van Niel.

Bacteria which appear to be identical to *Serratia marcescens* have been noted or described by several authors as attacking insects. Masera (1936a) in a comprehensive treatment of the subject states that as early as 1817 Rozier noticed a red coloration forming in the dead bodies of silkworms. This was again noticed by Pollini and Vasco in 1819, Re and Ascolese in 1837, etc. However, the credit for the actual isolation in 1886 of *Bacillus prodigiosus* from a silkworm larvae is due to Perroncito. Bandelli about the same time isolated *Bacillus prodigiosus* from the exterior of silkworms (*Bombyx mori*) and later stated that the red pigment did not appear until after the death of the larvae.

Metalnikov (1930) isolated a red-pigment former like *Bacillus prodigiosus* from the larvae of the gipsy moth, *Lymantria dispar* (L.) which was very virulent.

Zernhoff (1931) has reported that this bacillus is very virulent to the larvae of the wax moth, *Galleria mellonella* (L.), by inoculation but not by ingestion, whereas both methods result in infection in the larvae of the European corn borer, *Pyrausta nubialis* (Hbn.).

Masera has recently (1934 a and b, 1936 a, b, and c) published an extensive series of papers dealing with experimental studies of the pathogenicity of *Bacillus prodigiosus*. He found it to be fatal to *Pyrausta nubialis* by inoculation and by ingestion; while to *Bombyx mori* fatal when inoculated but not necessarily fatal when ingested, depending particularly on the age of the larvae. In the case of *Galleria melonella* he found it to be fatal only by inoculation, never by ingestion, and finally he found it to be nonpathogenic to the larvae of *Tenebrio molitor* L.

Lepesme (1937a, 1937b) has reported the occurrence of an epizoötic in laboratory-bred *Schistocerca gregaria* Forsk. caused by *Bacillus prodigiosus* and has shown that inoculation produces death in one or two days with the usual red coloration occurring (in this case mainly in the abdomen) while ingestion produces death only occasionally.

2. Non-pigment-forming rod

Principal Morphological Characteristics.—Small Gram negative rod. Non-motile. Endospores not present.

Catabolic Type.—Grows readily on ordinary peptone containing culture media under aerobic conditions. Facultative in respect to free O_2 growing readily in atmosphere of CO_2 on glucose containing media less readily in plain nutrient broth without glucose. Most of the carbohydrates fermented with production of acid and gas. Considerable amount of gas produced from glucose. $CO_2/H_2 = \frac{1}{1}$. Voges-Proskauer negative. Methyl red positive.

Consideration of these characters places this bacterium in the genus *Bacterium*.

Ancillary criteria for species differentiation are as follows:

Special Morphological Characteristics.—Quite variable in length. Filamentous forms observed, usually short rods, sometimes occurring in pairs.

Colony Morphology.—Plain agar (25° C. 4 d)—large, circular, entire edge (sometimes irregular) flat, opaque.

Gelatin plate—colonies smaller. No liquefaction.

No phase variation observed.

Metabolic Activities.—Acid and gas from arabinose, xylose, glucose, fructose, galactose, lactose, sucrose, maltose, mannitol, salicin.

Neither acid or gas from raffinose, inulin or dextrin.

Starch not hydrolyzed.

Gelatin not liquefied.

Milk acid clot—no digestion.

Indol: negative.

NH_3: positive.

H_2S: negative.

Catalase: positive.

Nitrite: reduced to nitrite, not to N_2 gas.

Methylene: blue and litmus reduced.

Citrate: positive.

Uric acid: positive.

Horse red blood cells not lysed.

Temperature Relations.

10° C.: fairly good growth.
25° C.: abundant growth.
37° C.: good growth.
} Optimum temperature about 25° C.

A comparison of these characteristics with those of various species of the genus *Bacterium* and more particularly with the genus *Escherichia* of Bergey does not find a perfect agreement with any of these. The fact that it is citrate and uric acid positive and has a lower optimum temperature than typical *E. coli* would seem to place it in the group of so-called coli-intermediates. The classification of this group is still quite unsettled and descriptions of known species quite incomplete, so we did not deem it worthwhile to carry out any further tests and hence will merely designate this organism as a species of the genus *Bacterium* as used by Kluyver and van Niel (1936) closely related to *Bacterium neopolitanum*, differing from this species in certain fermentation reactions and a lower optimum temperature. *Bacterium neopolitanum*, according to Topley and Wilson (1936), might be considered as another strain of *Bacterium coli*.

A few words might be said about previous bacteriological work on organisms isolated from insects. Many new species have been described. (For a partial cataloguing see Sweetman, 1936). However, many of these species were very inadequately described, the description given being usually quite insufficient for species differentiation. New specific and generic names were often given on the basis of pathogenicity to a certain insect, which to us seems quite unwarranted. Also, the names assigned often do not follow any of the usual systems of bacterial classifications. Some of them, e. g., *Bacillus sphingidis* (White) and *Bacillus noctuarum* (White) have subsequently been assigned to the genus *Escherichia* in Bergey's manual. The fault probably lies in the confusion prevailing at present in bacterial taxonomy. The investigator sometimes does not know which of the characters studied is more important. Often a valuable test is not performed because its importance is not realized, while a number of quite insignificant observations are laboriously made.

SUMMARY

Two new bacterial diseases of termites have been studied. This is apparently the first record in the order Isoptera.

Symptoms due to both diseases are given. *Serratia marcescens* generally causes the head and appendages of the dead termite to turn red. *Bacterium* sp. causes the head, especially, to turn black.

Tests for pathogenicity show: (1) For feeding experiments; 50 per cent mortality due to *Serratia marcescens*, and 22 per cent mortality due to *Bacterium* sp. (2) For inoculation experiments; 90 to 100 per cent mortality due to *Serratia marcescens* and 60 per cent mortality due to *Bacterium* sp.

Extensive genera and species differentiation tests are listed for each species of bacteria.

A short historical sketch is given of the records of the occurrence of *Serratia marcescens* in other insects.

ACKNOWLEDGMENTS

The authors are very grateful for the interest shown in this problem by Professor S. F. Light of the Zoology Department of the University of California, in whose laboratory this study was undertaken. Much credit for assistance rendered is also due to the United States Works Progress Administration through its project O. P. 165–03–7999.

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THE EFFECT OF TEMPERATURE UPON THE OXYGEN REQUIREMENTS OF CERTAIN ADULT INSECTS AND INSECT EGGS[1]

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It has been known since the early part of the Nineteenth Century that when the temperature of the medium surrounding a cold blooded animal is changed there is a change in the amount of oxygen required to support its basal metabolism. At the present time there exists considerable disagreement as to the way these effects of temperature-changes manifest themselves. Some workers have found that, for each unit rise in temperature, the amount of oxygen consumed is multiplied by a factor which is constant for the form studied throughout the none-injurious range of temperature; others have found that, for each unit rise in temperature, the amount of oxygen consumed is multiplied by a factor which becomes steadily smaller as the temperature rises; while still others have found that within certain temperature limits the rate of respiration is greatly accelerated by a rise in temperature while within other temperature limits there is but slight, if any, acceleration due to a rise in temperature.

PART I. EFFECT OF TEMPERATURE UPON THE OXYGEN REQUIREMENTS OF THE ADULT CLUSTER FLY (POLLENIA RUDIS FABRICIUS)

The first part of the present study was undertaken to determine the influence of different temperatures upon the rate of oxygen consumption of overwintering male and female adults of the cluster fly (*Pollenia rudis* Fabricius). A point of particular interest was the determination of any measurable differences in the relationship between temperature and oxygen consumption above and below 10° C. Above this point the insect's phototropic responses are positive and flight may be maintained while at lower temperatures it exhibits a negative phototropism and crawls into crevices and other shelters to form clusters, making no efforts to fly even when disturbed.

[1]Part of the material in this paper was presented in partial fulfillment of the requirements of the degree of Doctor of Philosophy at Cornell, June, 1936, and part was done later in the laboratories of Cornell University through the courtesy and co-operation of the Graduate School and the Departments of Entomology and Plant Pathology.

Methods.—For the purpose of the present study a modification of Thunberg's (1905) microrespirometer was used. This modification is the one used by Fenn (1927) in his study of the gas exchange of nerve tissue. Results were obtained from the use of individual flies. No attempt was made to prohibit movement after the insect was placed in the respirometer flask although every precaution was taken to remove stimuli which might excite movement. The stock of flies was kept in cages in a refrigerator at a temperature of 6° C., a point low enough to keep them motionless. Flies to be used were placed in cold vials at least 24 hours before being taken from the refrigerator. During the transfer from the refrigerator to the respirometer the vial containing the fly was kept inside a hollow block of cold insulating material. In this way the fly never became warm enough to awake from its torpor before it was inside the respirometer flask. At the beginning of the studies it was observed that flies, which were allowed to become warm enough to move about freely and possibly struggle before being placed in the apparatus, often showed an abnormally high rate of respiration which would be reduced gradually until a constant was reached from twelve to twenty-four hours later, regardless of the bath temperature. Farrar (1931) reported results somewhat similar to this when he obtained the respiration rate of honey bees kept at a temperature so low as to prohibit movement. Figures obtained two hours after they were placed in the apparatus were much higher than those obtained after six hours or longer. The inadvisability of attempting to bind or otherwise confine the insects is to some degree confirmed by the results obtained by Fink (1926) who followed this practice with adults of the Colorado Potato Beetle and, if we are to assume that he carried on his work at a temperature in the neighborhood of 21° C., obtained figures for oxygen consumption which vary from 55 to 175 times as great as those obtained in the present experiments for the cluster fly at the same temperature. The respirometer rested in rubber supports while the water bath in order to eliminate vibration and the respirometer flasks were painted black to shut out light.

Results.—Oxygen consumption of overwintering adults of both sexes of the cluster fly was measured throughout a range of temperatures extending from —2.6° C. to 43.75° C. The measurements of oxygen consumption were expressed in cubic millimeters per milligram of insect weight per minute. They ranged from .0005 cu. mm. per mg. per min. at —2.6° C. to .0758 cu. mm. per mg. per min. at 38.75° C. Up to this point there was always an increase in gas exchange as the temperature rose, but above this range the oxygen consumption ordinarily became smaller with a further increase in temperature. Individual flies responded differently to these extreme temperatures, most of them being fatally injured by temperatures above 43° C. while some were only partially paralyzed or apparently uninjured by exposures to 45° C.

Similar depressions of the respiratory rate at high temperatures have been noted by other workers, but due to the fact that there was observed to be a great variation in individual response no attempt was made to study the respiratory behavior of the insects above 38.75° C.

which seemed to be near the upper limit of the non-injurious temperature range.

The figures presented here are obtained from the records of 104 runs which averaged about two and one-half hours duration for each

TABLE I

MEAN VALUES FOR TEMPERATURE AND OXYGEN CONSUMPTION FOR THE CLUSTER FLY. EACH VALUE IS THE MEAN OF A 2° C. INTERVAL WHICH OVERLAPS 1° C. WITH THE ADJACENT 2° C. INTERVALS.

Temperature Interval, ° C.	Mean Temperature, ° C.	Mean Oxygen Consumption, cu. mm. per mg. per min.	Number of Experiments
—3 – —1	—1.8	.0008	10
—2 – 1	—1.1	.0010	8
0 – 2	0.9	.0012	5
1 – 4	2.8	.0022	5
3 – 5	4.0	.0026	5
4 – 6	4.9	.0028	3
5 – 7	5.7	.0047	2
6 – 8	7.2	.0045	4
7 – 9	8.0	.0040	8
8 – 10	8.9	.0049	10
9 – 11	9.9	.0052	9
10 – 12	10.9	.0069	7
11 – 13	11.9	.0091	9
12 – 14	12.4	.0092	8
13 – 15	14.0	.0100	7
14 – 16	14.9	.0102	9
15 – 17	16.1	.0122	9
16 – 18	17.0	.0119	9
17 – 19	17.7	.0108	5
18 – 20	18.9	.0141	3
19 – 21	19.7	.0142	4
20 – 22	20.7	.0125	3
21 – 24	22.6	.0153	3
23 – 25	23.5	.0180	4
24 – 26	24.5	.0184	4
25 – 29	26.7	.0196	4
28 – 30	28.9	.0231	4
29 – 31	30.0	.0237	4
30 – 32	30.8	.0234	3
31 – 33	31.9	.0308	2
32 – 34	33.3	.0339	5
33 – 35	33.8	.0324	7
34 – 36	34.9	.0362	7
35 – 37	35.9	.0464	7
36 – 39	37.6	.0617	7

temperature-oxygen consumption value determined. The first step in the interpretation of the results was to plot the temperature and oxygen consumption values of the individual experiments. These are shown on Chart I as solid black circles. To locate the path of a curve representing the mean values of the observations, they were grouped by

intervals of 1° C. and the mean oxygen consumption and temperature calculated for each interval. When plotted these means were found to show considerable zigzag fluctuation and in order to reduce the extremes of fluctuation the means of each of these 1° C. intervals was averaged with the one next above it, the new mean values being weighted according to the number of observations furnishing the original averages. This second series of means, therefore, is made up of mean values for 2° C. intervals which overlap for a space of 1° C. They are indicated as open circles on Chart II. They clearly show that a curve fitted to them would have to change its slope at about 12.5° C.

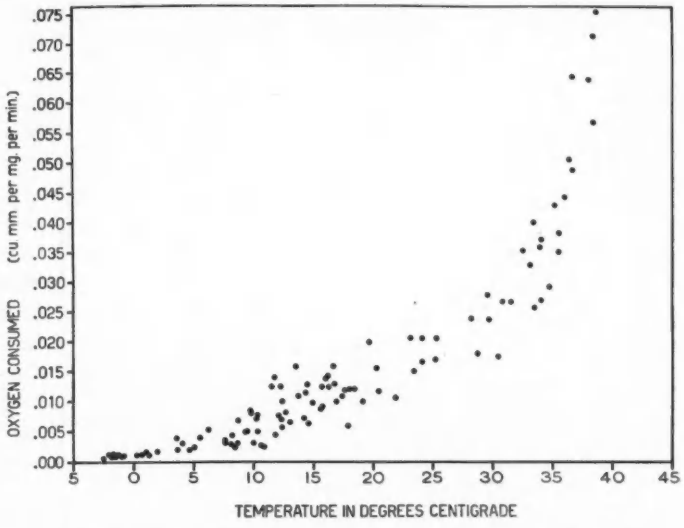

CHART I. Individual observations for oxygen consumption and temperature for cluster fly.

To determine how closely the mean values might follow mathematical curves they were plotted on semi-logarithmic or rate-of-change paper. On such a projection an exponential curve appears as a straight line. The mean values shown in Chart II are shown on such a projection in Chart III. Straight lines were drawn which would best fit the means and are shown on Chart III and represent two exponential equations which give Q_{10} values of 5.50 and 1.75 respectively when van't Hoff's rule is applied. The principle of van't Hoff's theory (1896) regarding the effect of heat on a chemical reaction does not apply throughout the whole range of observations but it does seem that, if we consider the relationship to be expressed by two successive curves, the oxygen consumption-temperature relationship follows the theory which he proposed, even though the rate of increase in reaction speed for the

first curve is 5.50 times for each ten degree rise rather than two to three times as he anticipated for most chemical reactions.

It will be seen that the mean values follow the mathematical curves quite closely except where they are pulled away by averages of intervals where there are but few observations or where there are one or two widely divergent observations. There is considerable doubt as to the possibility of fitting an exponential curve to the means above 33.5° C. since there is a probability that the irritating effects of high temperature are beginning to be felt above this point and that the metabolism can no longer be considered to be basal.

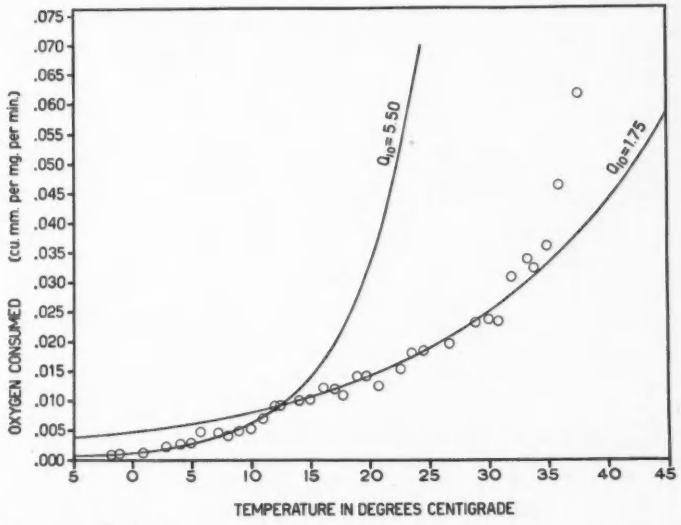

CHART II. 2° C. mean values of oxygen consumption and temperature for cluster fly.

The next step was to apply the data to Arrhenius' (1915) formula for critical thermal increment: $\frac{K_2}{K_1} = e^{\frac{\mu}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)}$ in which K_1 is the rate of reaction at one absolute temperature T_1, K_2 is the rate of reaction at a second and higher absolute temperature T_2, R is the molar gas constant (ordinarily given a value of 2) and μ is a constant for the reaction throughout the range. This was done to obtain values for critical thermal increment or μ which could be compared with values obtained by other workers from respiration studies made on insects and other cold blooded animals. Calculating for the value of μ in the equation it was found that between —1.85° C. and 10.9° C. μ was equal to 25,640 while between 14.0° C. and 28.9° C. μ equals 9,670.

These values differ considerably from those established by Crozier (1924) as the standard for respiratory activity. The change in value occurs at 12.5° C. instead of 15° C. and the values of μ are 9,670 and 25,640 rather than 11,500 and 16,100–16,700, respectively.

Discussion.—A compound curve such as is here presented is different from any of the published curves which are based on actual data but does bear considerable resemblance to an hypothetical curve of respiration for plants and cold blooded animals which Pütter (1914) has figured. He concluded that, although respiration is a reaction which is affected by temperature according to van't Hoff's rule, a single curve

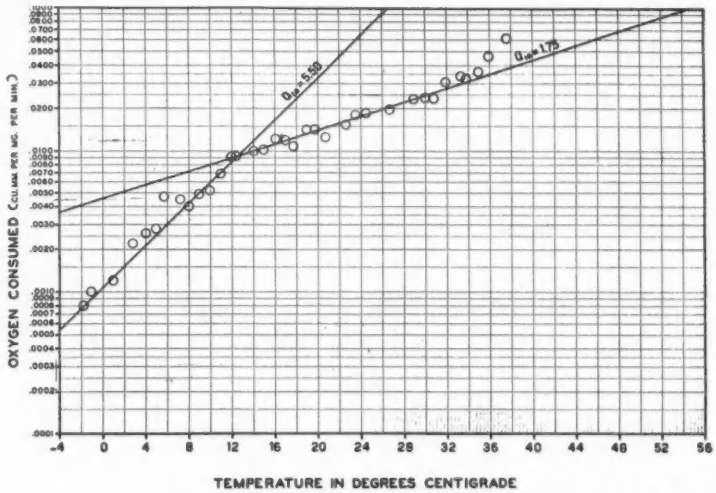

CHART III. 2° C. mean values of oxygen consumption and temperature for cluster fly plotted on rate-of-change paper.

is not sufficient to show the relationship throughout the whole range of temperatures. From the lowest limit to the highest the speed of the reaction is influenced in turn by three factors. He figures a curve in which, during the interval from 0° C. to 5° C., the permeability of the cells to oxygen is considered to be the limiting factor and respiration follows a curve with a Q_{10} of 8; from 5° C. to 15° C. the rate of an ordinary oxidation process is assumed to be the only limiting factor and respiration follows a curve with a Q_{10} of 2; above 15° C. a lethal factor, increasing with Q_{10} of 16, begins to pull the respiration curve down away from the path it has been following, bringing about a steady reduction in its Q_{10} value until there is an actual reduction in the amount of oxygen used and death shortly follows. In the present study, an increase in the value of Q_{10} above 33.5° C. is considered to be the first evidence of the irritating effects of high temperature, brought about by the stimulation of bodily activity incident to the increasing

discomfort of temperatures above this point. It is possible that narcotized specimens might furnish a curve whose upper range would resemble that of the one shown by Pütter.

The mean values for oxygen consumption between —2.6° C. and 33.5° C. appear to follow two separate and simple exponential curves. There is no evidence of a diminishing value for Q_{10} within the limits of either of them as is the case in curves obtained by Krogh (1914), Orr (1925) and Rogers (1929) when measuring the rates of respiration of immature insects. Krogh's curves showing the effects of temperature upon the velocity of development of Tenebrio pupae have been criticised by Shelford (1929) who says that, while "standard metabolism changes in rate as temperature is varied in a manner not altogether discordant with Q_{10} as a constant, but conforming more closely with Arrhenius' formula," "activity and development on the other hand do not conform to either of these laws but do conform in part to the century old idea of the equilateral hyperbola." This difference of opinion would have no part in the present discussion except for the fact that Krogh reasons that the temperature-respiration curve of an animal should follow the same mathematical formula as the temperature-velocity of development curve. Krogh's study of Tenebrio respiration is made upon pupae which are undergoing developmental changes and it is highly probable that the curve which he obtains is of a more complicated nature than that which would be obtained from a study of Tenebrio adults where basal metabolism would not be influenced by the requirements of metamorphosis. Janisch (1932) demonstrates quite clearly that temperature-respiration curves such as Krogh obtains and temperature-velocity of development curves which Krogh, Shelford and others obtain are reciprocals of catenary curves, the resultants, in each case, of two crossing exponential curves. Such a reciprocal curve has a straight portion which resembles the reciprocal of an equilateral hyperbola but the lower end has a definite bend upward and the upper end bends downward. It would appear that the data of Krogh, Shelford and Janisch might fit similar mathematical formulae if carried out to similar temperature limits.

Those who have made temperature-respiration studies of adult insects have failed to report such caternary curves and obtain data which will fit exponential curves. Bütschli (1874), Vernon (1897), Battelli and Stern (1913) and Potonie (1924) obtained data from non-hibernating adult insects which can be expressed in each case by a single exponential curve.

A comparison of Vernon's (1897) data with the results obtained here is of interest. The one insect which he studied, the non-hibernating cockroach, furnished a single temperature-carbon dioxide production curve which is exponential in character throughout the range studied. His work with other cold blooded animals gave quite different results. He claimed that there was no increase in respiration between 10° C. and 18° C. although a rise in temperature brought about a sharp increase at any point above or below this interval.

There is some evidence to show that hibernating nymphal forms follow the same temperature-respiration relationship. Bodine (1921),

studying the oxygen consumption of summer nymphs of *Melanoplus femur-rubrum*, reported a Q_{10} value of 1.1 to 1.5 for the temperature range from 0° C. to 25° C. Bodine (1925) later obtained data from overwintering nymphs of *Cortophaga viridifasciata* which give a Q_{10} value of at least 3.5 for the interval between 4° C. and 15° C. Kleinman (1934) studying the respiratory quotient of overwintering nymphs of the same species, obtained data for oxygen consumption which would give a Q_{10} value of at least 5.5 for the interval between 7° C. and 15° C., while from 15° C. to 34° C. the Q_{10} value fluctuates between 3.0 and 2.0.

A study of the respiratory requirements of the cluster fly at temperatures below 12.5° C. leads to the conclusion that they express an adaptation favoring successful hibernation. Within the limits of hibernation, a rapid decrease in the use of oxygen as the temperature drops or, conversely, a rapid increase as the temperature rises, can be considered to be a factor favoring rapid and economical adjustment to environment. A smaller value for Q_{10} than the one obtained, for that part of the curve which lies within the range of hibernation, would require that the insect be brought to temperatures lower than those studied in order to reach the observed figures for oxygen consumption. This can be demonstrated on Chart III if the line representing the van't Hoff curve fitting the data between 12.5° C. and 33.5° C. is extended downward until it crosses the respiration level of .0008 cu. mm. of oxygen per mg. per min., the lowest value measured. If the insect's temperature-respiration responses should continue to follow this curve below 12.5° C. we find that the temperature must drop to a point in the neighborhood of —32° C. before the rate of gas exchange will be reduced to that which has been measured for —1.8° C. At a temperature of —1.8° C. on this hypothetical curve we would find that the insect needed five units of oxygen in comparison to the one unit necessary in the observed data. The animal could spend five days in hibernation at the observed rate of food oxidation as cheaply as it could but one day at the same temperature under this hypothetical temperature-respiration relationship. A minimum of respiration during hibernation would leave a maximum of unoxidised food reserve in the fat bodies to support activity in the spring.

PART II. THE EFFECT OF TEMPERATURE UPON THE OXYGEN REQUIREMENTS OF THE ADULT FEMALE CITRUS MEALYBUG (PSEUDOCOCCUS CITRI RISSO)

The second part of the present study was undertaken in order to check the data obtained from the cluster fly against that which might be obtained from a strictly non-hibernating form. For this purpose the citrus mealybug (*Pseudococcus citri* Risso) was selected. It was abundant in the insectary greenhouse where a stock was maintained for experimental purposes and its sluggish habits indicated that it would serve admirably as a subject for such a study.

Methods.—The same apparatus was used and procedure followed as in the case of the cluster fly, with these exceptions: single individuals were not used due to the small size of the insects which, on the average

obtained from the total weight of the 320 specimens used, weighed 1.32 mgs. each; and the insects were not kept at a constant temperature before being used. They were removed from the plants in the green-

TABLE II

MEAN VALUES FOR TEMPERATURE AND OXYGEN CONSUMPTION FOR THE CITRUS MEALYBUG. EACH VALUE IS THE MEAN OF A 2° C. INTERVAL WHICH OVERLAPS 1° C. WITH THE ADJACENT INTERVALS.

Temperature Interval, ° C.	Mean Temperature, ° C.	Mean Oxygen Consumption cu. mm. per mg. per Minute	Number of Experiments
2 – 4	2.2	.0020	1
3 – 5	4.5	.0031	1
4 – 6	5.1	.0031	3
5 – 7	5.9	.0033	4
6 – 8	7.1	.0037	4
7 – 9	8.2	.0044	4
8 – 10	8.9	.0049	3
9 – 11	10.4	.0057	3
10 – 12	11.1	.0057	3
11 – 13	12.2	.0064	3
12 – 14	13.0	.0071	4
13 – 15	14.2	.0081	5
14 – 16	15.0	.0089	4
15 – 17	16.1	.0088	2
16 – 18	17.3	.0117	5
17 – 19	17.8	.0124	6
18 – 20	19.0	.0140	5
19 – 21	20.2	.0171	10
20 – 22	20.9	.0179	13
21 – 23	21.9	.0180	12
22 – 24	23.1	.0199	14
23 – 25	24.2	.0235	20
24 – 26	24.6	.0254	14
25 – 27	26.3	.0294	6
26 – 28	27.1	.0312	6
27 – 29	28.2	.0324	6
28 – 30	28.9	.0334	7
29 – 31	30.0	.0355	6
30 – 32	30.9	.0362	4
31 – 33	32.0	.0373	4
32 – 34	33.0	.0375	5
33 – 35	34.1	.0360	6
34 – 36	35.1	.0373	5
35 – 37	36.2	.0408	6
36 – 38	37.1	.0391	7
37 – 39	38.0	.0361	5
38 – 40	39.1	.0351	5
39 – 41	40.1	.0363	6
40 – 42	40.6	.0384	3
41 – 43	42.2	.0411	2
42 – 44	42.7	.0396	4
43 – 45	43.5	.0413	3
44 – 46	45.2	.0459	3
45 – 47	45.6	.0450	2
46 – 48	47.6	.0585	1
47 – 49	48.3	.0273	4
48 – 50	48.5	.0169	3

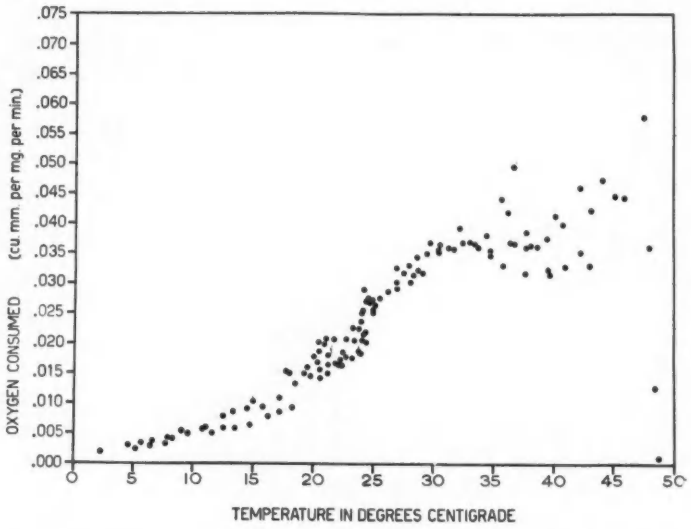

CHART IV. Individual observations for oxygen consumption and temperature for citrus mealybug.

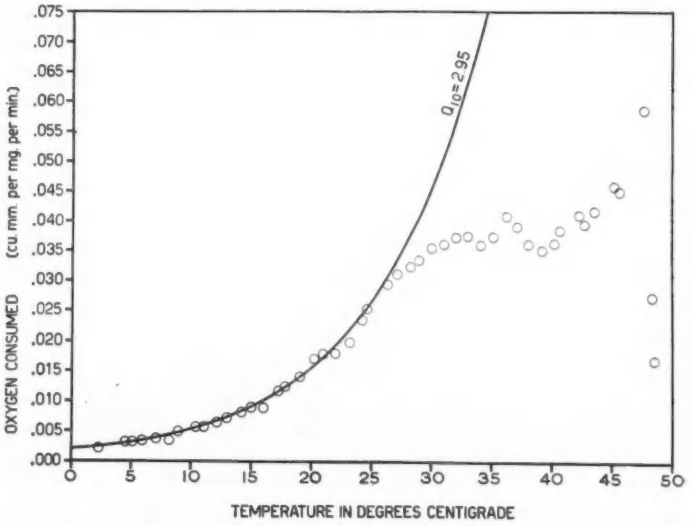

CHART V. 2° mean values of oxygen consumption and temperature for citrus mealybug.

house as gently as possible with a camel's hair brush, placed in vials and brought to the laboratory where they were sorted and a representative group of mature specimens was counted, weighed and placed in the respirometer. Twenty-five such groups were used in all, totaling 320 individuals and averaging 16.9 mgs. in weight per group.

Results.—From these 25 groups 119 temperature-oxygen consumption values were obtained, ranging from .0020 cu. mm. of oxygen per mg. per minute at 2.25° C. to .0012 cu. mm. of oxygen per mg. per minute at 48.9° C. These temperature extremes represent the lowest oxygen consumption figures obtained. The greatest oxygen con-

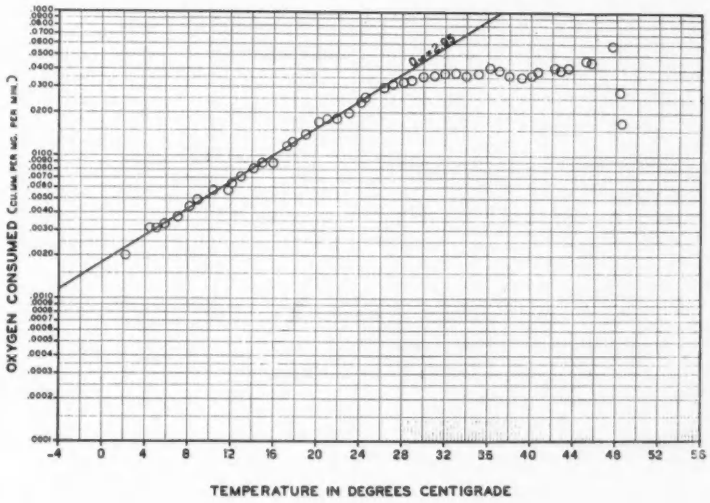

CHART VI. 2° mean values of oxygen consumption and temperature plotted on rate-of-change paper: female citrus mealybug.

sumption was observed at 47.6° C. where .0585 cu. mm. per mg. per minute was measured. The 119 temperature-oxygen consumption values obtained are shown plotted on Chart IV. These values were averaged for 2° C. intervals which overlapped 1° C., as in the previous study, so that any possible break in the mean curve might be more closely located. These mean values are given in Table II and are plotted on Chart V along with the exponential curve which most closely fits them, a curve with a Q_{10} value of 2.95. It will be seen that the mean values follow the curve quite closely up to about 27° C. Above this point they depart sharply although but little scattering is observed until 36° C. is reached. Above that point there is wide divergence. On Chart VI the mean values are shown plotted on rate-of-change paper and it is seen that they follow the exponential curve, shown as a straight line, from the lowest temperature up to about 27° C. Above

that point the departure from the curve does not seem to follow a new exponential curve but seems to be in the nature of a slight bending downward away from the original straight line followed by an irregular course upward until a sharp drop occurs down to the base line where respiration was observed to stop. But one group of insects was subjected to temperatures above 45° C. since it was observed that temperatures above 35° C. brought about irregular movements and struggles which were considered to be responsible for the scattered values obtained above this point and which would remove the animals from a state of basal metabolism. Below 35° C. the values obtained seem to be those of basal metabolism.

Discussion.—From 2.25° C. to 27.0° C. the temperature-oxygen consumption relationship seems to be entirely in accord with the theory of van't Hoff, following an exponential curve with a Q_{10} value of 2.95. The exact interpretation of the mean values after they depart from the exponential curve is hard to determine due to the short interval in which they continue to represent basal metabolic conditions but it appears that at 27° C. heat begins to act as a retarding agent on oxygen consumption, this retarding action becoming more pronounced as the temperature rises. This is in accord with the view held by Pütter (1914) referred to above. To test his theory satisfactorily an animal would have to be studied which would not depart from basal metabolism at any point between the lower and upper lethal temperature limits.

TABLE III

MEAN VALUES EOR TEMPERATURE AND OXYGEN CONSUMPTION FOR EGGS OF THE SPOTTED MILKWEED BUG

Temperature Interval, ° C.	Mean Temperature, ° C.	Mean O_2 Consumption per cu. mm. per mg. per min.	Number of Determinations Furnishing the Mean
1.25 – 3.75	2.87	.0005	6
3.75 – 6.25	4.41	.0006	6
6.25 – 8.75	6.50	.0012	2
8.75 – 11.25	8.75	.0014	2
11.25 – 13.75	12.58	.0025	6
13.75 – 16.25	15.10	.0035	5
16.25 – 18.75	17.00	.0045	3
18.75 – 21.25	21.00	.0068	2
21.25 – 23.75	22.38	.0070	8
23.75 – 26.25	24.82	.0083	10
26.25 – 28.75	27.67	.0124	4
28.75 – 31.25	30.06	.0117	4
31.25 – 33.75	32.60	.0139	7
33.75 – 36.25	35.16	.0160	6
36.25 – 38.75	37.64	.0151	7
38.75 – 41.25	40.07	.0138	10
41.25 – 43.75	42.50	.0120	4
43.75 – 46.25	45.00	.0104	5
46.25 – 48.75	47.50	.0090	2

PART III. THE EFFECT OF TEMPERATURE UPON THE OXYGEN REQUIREMENTS OF EGGS OF THE SPOTTED MILKWEED BUG (ONCAPELTUS FASCIATUS DALLAS)

The third part of the present study was undertaken for two primary reasons: first, to be able to measure the oxygen requirements of basal metabolism at temperatures higher than was found to be possible with the two previous forms; and second, to be able to compare the temperature-respiration relationship of a rapidly developing form with that of the mature forms previously studied.

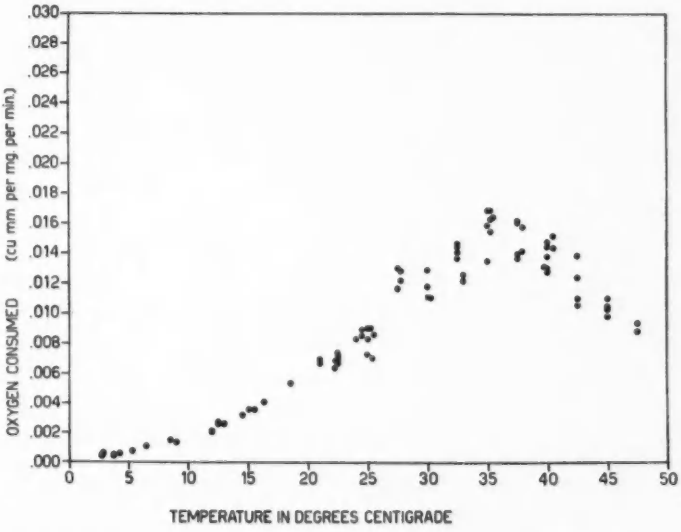

CHART VII. Eggs of *Oncapeltus fasciatus* Dallas. All determinations for temperature and oxygen consumption.

Methods.—All eggs laid were removed from a culture of the insects every 24 hours, kept in the constant temperature room with the insects for 48 hours longer and then cleaned, weighed and placed in the respirometers. Two respirometers were used at all times, one being considerably more sensitive than the other. In the more sensitive one 14 samples of eggs were used which averaged 30.4 mg. per sample and 49 temperature-oxygen determinations were obtained, based on runs averaging 2 hours and 40 minutes in length. In the less sensitive, but no less accurate, respirometer 16 samples, averaging 73.3 mg. per sample, were used and 50 determinations were obtained, based on runs which averaged 4 hours and 13 minutes in length.

Results.—Oxygen consumption values ranging from .0004 cu. mm. per mg. per min. at 3.0° C. to .0169 cu. mm. per mg. per min. at 35.0° C. All values obtained are shown on Chart VII. Since, for the most part,

the determinations were made at points 2.5° C. apart, the means for these groups of values were determined and are shown on Chart VIII along with the curve fitted to them. The values of these means are listed in Table III. The same means and the same curve are shown projected semi-logarithmically on Chart IX. The difference between this curve and the one obtained from the mealybugs will be seen at once. Whereas the mealybug data follows a definite exponential curve up to about 26.0° C. and then departs abruptly from it in a catenary fashion as some inhibiting factor or factors begin to be manifest, the curve obtained from the *Oncapeltus* eggs is of a catenary nature

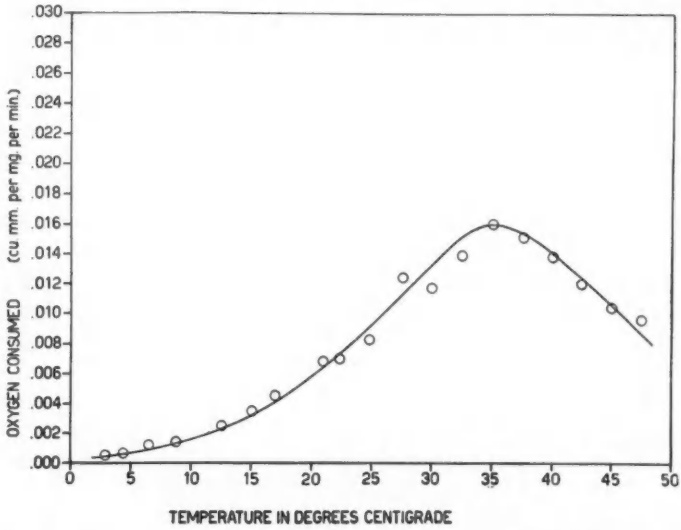

CHART VIII. Eggs of *Oncapeltus fasciatus* Dallas. Mean values for temperature and oxygen consumption.

throughout the range studied, the inhibiting factor or factors increasing their influence as the temperature rises, thus reducing the rate of increase in oxygen consumption until above 35.0° C. there is a decrease in oxygen consumption with a rise in temperature.

Discussion.—The curve obtained from the study of the *Oncapeltus* eggs is of the same type as that obtained by Krogh (1914), Orr (1925) and Rogers (1929) from studies made upon immature insects. A comparison of the three studies made in the present paper would indicate that the temperature-respiration relationship of insects cannot be expressed by any one curve or formula. Various factors may influence it, apparently, depending upon the state of development of the animal and the life habits to which it is adapted. What these factors are and how they function is not apparent from the data at hand.

The study was not carried to temperatures above 47.5° C. because of the lethal nature of such temperatures. At 45.0° C. about 1 hour and 45 minutes of even respiration rate could be counted on before it began to fall off rapidly and ceased entirely about two hours later. At 47.5° C. only about 45 minutes of even respiration rate could be counted on, after which it fell off rapidly, reaching zero about one hour later. Readings were made at short intervals at these higher temperatures and no data was used after the respiration rate was seen to start dropping.

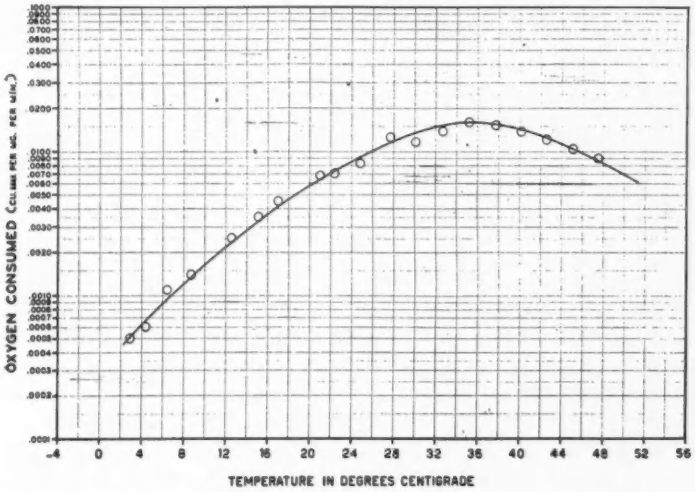

CHART IX. Eggs of *Oncapeltus fasciatus* Dallas. Mean values for temperature and oxygen consumption on rate-of-change paper.

SUMMARY

1. Overwintering adults of both sexes of the cluster fly (*Pollenia rudis* Fab.) increase their rate of oxygen consumption under the influence of an increase in temperature. This rise in respiratory rate follows a composite curve made up of two successive exponential curves to which the theories of van't Hoff and Arrhenius are considered to be applicable. The data follows the first curve, which has a Q_{10} value of 5.50, from —2.6° C. to 12.5 °C. From 12.5° C. to about 33.5° C. the data follows a second curve which has a Q_{10} value of 1.75. Above 33.5° C. the flies became restless and the relationship seems to be no longer that of purely basal metabolism.

2. A larger value for van't Hoff's Q_{10} or Arrhenius' μ for that part of the curve which lies within the temperature limits of hibernation, than is found for the curve in the range of normal, free moving, activity, is considered to be of an advantage to the insect in its method of passing the winter.

3. Adult females of the citrus mealybug (*Pseudococcus citri* Risso) were found to increase their rate of oxygen consumption under the influence of an increase in temperature. From 2.25° C. to 27.0° C. this relationship is in accord with the theories of van't Hoff and Arrhenius in regard to the effect of heat upon the speed of a chemical reaction and can be expressed by an exponential curve with a Q_{10} value of 2.95. Above 27.0° C. the values for oxygen consumption depart sharply from this curve and up to 35.0° C. they seem to follow a catenary curve where the value for Q_{10} is being steadily reduced. Above 35.0° C. the insects become restless and seem to be no longer in a state of basal metabolism.

4. Eggs of the spotted milkweed bug (*Oncapeltus fasciatus* Dallas) averaging from 48 to 72 hours old, were found to increase their rate of oxygen consumption with an increase in temperature from 3.0° C. to 35.0° C. Above that point an increase in temperature resulted in a decrease in oxygen consumption which became more pronounced as the temperature continued to rise. The temperature-oxygen consumption relationship seems to be of a catenary nature throughout the range studied and at no time does it appear to follow van't Hoff's theory regarding the effect of heat on the speed of a simple chemical reaction. No studies were made above 47.5° C. because of the rapidity with which the eggs were killed above that point.

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LLOYDIA, A QUARTERLY JOURNAL OF BIOLOGICAL SCIENCE, published by THE LLOYD LIBRARY OF NATURAL HISTORY, 309 West Court St., Cincinnati, Ohio. Price $3.00 per year.

We have before us Vol. I, Nos. 1–4, 1938, which copy of 254 pages is the whole volume for that year. It is printed on glossy, heavy paper that takes illustrations well. The type block is 4.5 x 7 inches, which is used as a single column.

The contents of the first volume are five articles which are morphological or taxonomic. One by H. K. Townes on the Ichneumon genus Netelia, and one by D. M. DeLong on Phlepsius, are entomological. The Editor is the botanist Professor Theodor Just of Notre Dame University, who is also Editor of the Midland Naturalist. He is assisted by Professor John H. Hoskins of the Botany Department of the University of Cincinnati.

The Lloyd Library was founded in 1864 by J. U. Lloyd of the Lloyd family who have been pharmaceutical manufacturers in Cincinnati for nearly a hundred years. It houses 60,000 volumes, 50,000 pamphlets and receives annually 800 serials on botany, chemistry, pharmacy and zoology. The previous publications of the Library are discontinued. In their place is the journal Lloydia. We know enough of its financial and editorial background to feel certain that it will be a successful biological journal.—C. H. K.

NUTRITIONAL STUDIES OF THE CONFUSED FLOUR BEETLE (TRIBOLIUM CONFUSUM DUVAL) AND THE BEAN WEEVIL [ACANTHOSCELIDES OBTECTUS (SAY)][1]

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Nutritional studies on insects give a phylogenetic viewpoint in the science of nutrition and help us to the understanding of one of the many problems in insect ecology. A study was undertaken to determine the effect of various food factors upon the growth of two of our most common stored-product pests, the confused flour beetle (*Tribolium confusum* Duval) and the bean weevil (*Acanthoscelides obtectus* (Say)) with special reference to lipids and fat-soluble vitamins.

Chapman (1924) studied the confused flour beetle and found that a diet containing starch, wheat gluten, wheat germ, vitamin B in dextrin and salts gave almost exactly the same rate of development as the control in wheat flour. According to the findings of Sweetman and Palmer (1928) *Tribolium* may be reared on a fat-free diet and it has no absolute need for fat-soluble substances. It has been demonstrated that of the vitamins, this beetle requires only the vitamin B complex or several factors of this complex for its growth and development. Street and Palmer (1935) recently found that it requires a heat stable factor present in autoclaved yeast in addition to vitamin B_1. Bushnell (1938) studied the relation of nutritional levels to the growth of populations of this species and found that yeast appeared to enhance the egg production of females.

Very little work has been done on the food requirements of the bean weevil. Herford (1935) studied the influence of different larval foods upon the life of the adult and the correlation of the chemical composition of different species of seed with its effect on the activities of this species. She found that the

[1]The authors are indebted to Drs. G. F. MacLeod, W. T. M. Forbes and E. F. Phillips for their helpful suggestions and criticisms to this paper.

optimum food had a high carbohydrate content, but no attention was given to the accessory food factors.

EXPERIMENTS WITH THE CONFUSED FLOUR BEETLE

Twenty-four different diets were prepared and each was placed in a small bottle (4.7 x 12 cm.) which was covered with a piece of muslin. Ten newly-emerged beetles were obtained from a stock culture which had been bred for several generations in the laboratory, and after keeping for one to two days without food, they were transferred to each bottle containing twenty grams of the diet. The moisture content of the diets varied from eight to eleven per cent. For comparison whole wheat flour was used as normal diet. The beetles were examined at regular intervals. At the end of 49 and 94 days the total number of adults living in each bottle was counted and these data were taken as a measure of the nutritional value of various foods.

Throughout the experiments the insects were kept in a wooden box which maintained a temperature of 28–35° C. and a relative humidity of 50–70 per cent. To minimize the effects of light the insects were kept under practically dark conditions.

In preliminary experiments nineteen different diets were used. The composition of the diets are presented in Table I. Five per cent Wesson oil (cotton-seed oil) was added to all the diets except Nos. 17, 18, vitamin A-free diet, and the normal diet (whole wheat flour).

Three per cent Osborne-Mendel salt mixture (Hawk and Bergeim, 1937, p. 887) was added to all the diets except in the vitamin A-free diet, which was made up to contain 4% salt mixture and in the normal diet. A 3% salt mixture gave the diet a phosphorus composition of 0.21%. According to Nelson and Palmer (1935) the time of pupation of *T. confusum* is somewhat proportional to the amount of phosphorus in the ration, other factors being constant. The limiting amount of phosphorus or the amount of phosphorus that is essential but deficient for growth is probably below 0.2 per cent. Therefore in these experiments phosphorus was not a limiting factor.

The results of the preliminary experiments are summarized in Table I. From these data the following tentative conclusions were drawn: (1) *Tribolium* do not survive and grow in a diet largely made up of sucrose. (2) High protein diets seem to favor the increase of the beetle population. Forty per cent protein diet is distinctly better than five per cent protein diet. The optimum level of protein in the diet probably lies between 20–40 per cent. (3) Diets Nos. 5 and 6 seem to be about as good as the whole wheat flour. (4) Of the water-soluble vitamins, neither B_1 nor G (lactoflavin) alone fulfills the requirement for the growth of *Tribolium*. With regard to fat-soluble vitamins, A and D are not essential for the growth of the beetle. Neither cod liver oil nor Wesson oil at a five per cent level is injurious to the beetle. (5) Besides vitamin B_1 some factors in yeast are essential for the growth of the beetle.

Since the beetle cannot utilize sucrose, it was thought that the enzyme invertase might be absent in the gut of the insect. Experi-

ments, therefore, were conducted in which pure dextrose was substituted for sucrose in the diets.

In view of the fact that large numbers of beetles were obtained from the diets containing starch, it was thought that the cooked corn starch might contain some impurities such as proteins or other unknown factors which would accelerate or be essential to development. Purified corn starch was therefore used in a series of experiments to find out whether there was any differential effect upon the population growth.

TABLE I

THE GROWTH IN POPULATION OF *Tribolium confusum* AS AFFECTED BY DIFFERENT DIETS.

(Ten newly-emerged beetles were put on each diet at the start.)

Diet No.	Composition	Total Number of Living Adult Beetles Found After 49 Days
1	Casein 40, Sucrose 47, Yeast 5	5
2	Casein 20, Sucrose 67, Yeast 5	7
3	Casein 10, Sucrose 77, Yeast 5	9
4	Casein 5, Sucrose 82, Yeast 5	2
5	Casein 40, Cooked corn starch 47, Yeast 5	122
6	Casein 20, Cooked corn starch 67, Yeast 5	132
7	Casein 10, Cooked corn starch 77, Yeast 5	55
8	Casein 5, Cooked corn starch 82, Yeast 5	24
9	Casein 10, Sucrose 82	0
10	Casein 10, Sucrose 77, Yeast 5†	5
11	Casein 10, Sucrose 72, Yeast 10	8
12	Casein 10, Sucrose 72, Yeast 10 (Ether Ext.)	10
13	Casein 12, Sucrose 80, Cryst. Vitamin B_1 20γ%	1
14	Casein 12, Cooked corn starch 80, Cryst. Vitamin B_1 20γ%	1
15	Casein 12, Sucrose 79, Lactoflavin conc.* 1	1
16	Casein 12, Cooked corn starch 79, Lactoflavin conc. 1	9
17	Casein 10, Sucrose 77, Yeast 5, Cod liver oil 5	0
18	Casein 10, Cooked corn starch 77, Yeast 5, Cod liver oil 5	68
19	Vitamin A-free diet (Casein 18, Yeast 8, Cellulose 2, Salt mixture 4, Crisco 3, Cooked starch 65)	10
20	Whole wheat flour (Normal diet)	292
21	Whole wheat flour (Normal diet)	199

†This is a duplicate of diet No. 3.
*Lactoflavin from XXX liquor of the Borden Co., Bainbridge, N. Y.

The starch was purified according to the method suggested by Moeser (1917). The purified product contained 0.017 per cent of phosphorus and a very small amount of protein.

To obtain further information regarding vitamin A requirement additional experiments dealing with this question were conducted. To test whether or not a sterol would supply all the fats needed for the development of the beetle, a new diet which contained one per cent cholesterol was prepared and used in the experiments. All these experiments were run in duplicate.

The results of these experiments are presented in Table II. It will be seen that some of the conclusions drawn from the preliminary experiments are confirmed.

TABLE II

THE GROWTH IN POPULATION OF *Tribolium confusum* AS AFFECTED BY DIFFERENT DIETS.

(Ten newly-emerged beetles were put on each diet at the start.)

DIET No.	COMPOSITION	TOTAL NUMBER OF LIVING ADULT BEETLES FOUND AFTER	
		49 Days	94 Days
21A	Casein 20, Sucrose 67, Yeast 5	10	2
21B		10	2
22A	Casein 20, Dextrose 67, Yeast 5	10	7
22B		199	200
23A	Casein 20, Purified cooked corn starch 67, Yeast 5	64	72
23B		177	189
24A	Casein 20, Cooked corn starch 67, Yeast 5	272	276
24B		166	187
25A	Casein 20, Purified cooked corn starch 62, Yeast 10	53	68
25B		88	95
26A	Casein 20, Purified cooked corn starch 62, Yeast (Ether-extracted) 10	79	133
26B		50	94
27A	Vitamin A-free diet*	20	22
27B		15	11
28A	Casein 15, Cooked corn starch 77, Yeast (Ether-extracted) 5, Cholesterol 1	69	123
28B		61	265
29A	Whole wheat flour (Normal diet)	237	280
29B		150	210

3% Osborne-Mendel salt mixture was added to all the diets except Nos. 27A, 27B, 29A, and 29B.

5% Wesson oil (cotton-seed oil) was added to all the diets except Nos. 27A, 27B, 28A, 28B, 29A, and 29B.

*For composition of this diet, see Table I.

The beetles apparently can digest dextrose, and the population growth appeared to proceed normally in a diet containing dextrose as its only source of carbohydrate. The fact that the population did not grow in diet No. 22A was probably due to the lack of males among the ten beetles introduced.

There is no significant difference between the populations in the diets containing purified corn starch and in those containing common corn starch. This indicates that the impurities in the common cooked starch are negligible.

Doubling the amount of yeast in the diet did not result in any marked difference in numbers of beetles produced. The insect did not appear to require the ether-soluble fraction of yeast to complete growth.

Vitamin A was not absolutely essential for development, but in its absence the growth of the population was greatly retarded. This partly substantiates the findings of Sweetman and Palmer (1928).

The growth and development of the beetles was normal in the ration in which one per cent cholesterol was the only source of fat. No evidence is found, however, that a sterol is an essential growth factor as has been postulated by Hobson (1935).

It is interesting to note that the beetle population in the diets containing ether-extracted yeast (diet No. 26A, B), cholesterol (diet No. 28A, B), and in the normal diet (diet No. 29A, B) continued to grow after 49 days, while the rest had practically reached equilibrium by that time.

EXPERIMENTS WITH THE BEAN WEEVIL

In the experiments with the bean weevil, the method consisted essentially of modifying the normal food of the weevil by extraction or addition of various factors. The normal food was the red kidney

TABLE III

TRIPLICATE FEEDING EXPERIMENTS TO DETERMINE THE NUTRITIONAL REQUIREMENTS OF THE BEAN WEEVIL.

Diet No.	Composition	No. of Eggs put in the Diet	No. of Larvae Found	No. of Adults Emerged	Average Life-cycle* in Days
1	Normal diet (Kidney bean powder)	30	0	13	34.5
2	Ether-extracted normal diet	30	0	0	
3	Ether-extracted normal diet, 3.6% cotton-seed oil	30	0	0	
4	Diet No. 3, Vitamin D	30	2	0	
5	Diet No. 3, Vitamin A and D	30	2	0	
6	Autoclaved normal diet	30	0	0	
7	Diet No. 2, 3% cholesterol	30	9	1	41.0

All the insects were reared on pills made of red kidney bean powder.

*The life-cycle is defined as the time elapsing from the laying of the egg to the emergence of the adult.

bean, *Phaseolus vulgaris* L. Using finely ground bean powder as a stock, six different diets (Table III) were prepared. Since the larva of this species cannot live upon very loosely-packed particles such as powder or flour, each diet was pressed into small pills (10 mm. in diameter, 5 mm. in thickness) by a pill machine or packed in small gelatin capsules (20 mm. in length, 6 mm. in diameter) so as to offer a more normal feeding environment for the larvae. Three pills were placed in a vial (2 x 4 cm.) and 6 to 10 eggs introduced into it. The

vial was stoppered with a cotton plug. The eggs were of known age, carefully selected and supposedly capable of hatching. Two newly-hatched larvae were carefully transferred into each gelatin capsule. In order to provide adequate ventilation, two small holes were bored in each capsule. The vials and capsules were examined once a week until the time when adult emergence approached they were examined daily. The insects were kept in dark, at a temperature of 28–35° C. and a relative humidity of 50–70%. Each experiment with the pills was repeated three times and with the gelatin capsules, five times.

All vitamins used in these experiments were concentrates. For vitamin A and D high-grade cod liver oil was used, for vitamin D a reference oil for vitamin D assay of white rats was used. One to two drops being added to ten grams of food, they were thoroughly mixed together with ethyl alcohol and ether. The red kidney bean used to feed the weevil was found to contain 3.4 per cent fat. The fat-free diet was prepared by extracting the bean powder thoroughly with isopropyl ether. To destroy vitamin B_1 the bean powder was autoclaved under 15 pounds of pressure for 6 hours. The autoclaved bean appeared dark brown in color and had a special flavor.

The results obtained are summarized in Table III. The weevil successfully completed its development in pills made up of bean powder, but failed to grow in gelatin capsules. The weevil could not grow in an ether-extracted normal diet. Cotton-seed oil did not supply all the essentials removed by ether. The larva of the weevil could grow in a fat-free normal diet in the presence of vitamin D or A and D, but failed to complete its development. Vitamin B_1 appears to be essential. The weevil can complete its development, but at a very slow rate, in an ether-extracted normal diet if three per cent cholesterol were added to it. This indicated that a sterol may be essential for the development of this species.

SUMMARY AND CONCLUSIONS

The nutritional requirements of the confused flour beetle may be satisfied by a purified diet consisting of casein, corn starch, yeast, cotton-seed oil and Osborne-Mendel salt mixture. The beetle appears unable to utilize sucrose and possibly invertase is absent from the gut of the insect. The beetle needs some factors found in yeast besides vitamin B_1. No evidence indicates any need for fat-soluble vitamins A and D or the ether-soluble material found in yeast.

A technique for feeding the bean weevil a modified natural diet has been devised. The ether extract from the kidney bean appears to be essential for the growth and development of the weevil. Cholesterol can be substituted for the fat extracted from the normal diet, but development of the weevil is retarded.

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ATLAS OF THE SCALE INSECTS OF NORTH AMERICA, by G. F. Ferris, about 540 pages including 103 pls. 1938. 11x8½ inches. Photolith. Published by Stanford University Press, Stanford University, Calif. Price, unbound, $7.75, bound, $8.75.

This volume is the second in the series of volumes planned by Professor Ferris to cover the scale insects of North America. Its 103 plates cover 103 species. Each species calls for a title page, a page of text, a plate facing the text and a blank back to the plate. Thus each species uses a two leaf folder of four pages. The information desired in the text faces the plate where each can be used with the greatest convenience.

The author's original plan was to consider each species-folder as a separate publication, so that any purchaser need buy only those folders which concerned his locality or were otherwise of use to him. The unexpected happened. The sale proved to be largely of sets and volumes. Buyers for libraries, private or public, favor volumes. Small items are lost too easily. Where such a choice is possible the buying public determines the nature of the sale, in this case a sale of bound volumes. As Professor Ferris laments in the introduction to volume II, "The demand has been primarily for bound volumes, thus not merely defeating the so carefully devised original plan but even making it appear in some degree absurd. In a bound volume the blank pages and the repetition of the title-page material—the latter necessary if each unit is to be regarded as a separate publication—become quite incongruous!"

The reviewer has no personal feelings against the plan of the Atlas or its author's methods. We still admire it for its scope, for the quality dependent on unrelenting effort over nearly thirty years on the study of scale insects, and for its really remarkable illustrations. The latter are published in a size large enough to display adequately the details of structure so necessary in illustrations of Coccidae. Full, carefully drawn figures help to fix the species with which the author deals. Whether he has the correct name on it is another type of problem. We sometimes feel that in much of taxonomic literature more emphasis has been placed on names than on the exact delineation of the characters of the species. In some catalogues the species itself is almost lost sight of. Ferris brings the species to the front, and vividly. We are for this work even if it does have 103 title pages.

Epilogue: We have to examine the volume minutely to be certain that it is the product of the photolith process. It is clean, and brilliantly printed with no black e's and m's. If printed it could have been double-columned for ease in reading but the still somewhat ragged right edge inclines the publisher to as few right edges as possible. Gradually lithoprint is coming into its own. Perhaps we can look forward to ample medium priced publications such as science has not enjoyed since the recent high unionization of the printing trades.—C. H. K.

A NEW SPECIES OF HESPERIA

(Lepidoptera, Hesperiidae)

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During a year of study of this genus several possibly undescribed species have come to my notice. Unfortunately, with one exception they belong to the great assemblage of western forms in which the genitalia are not distinctive. To this group belong the named forms or species, *idaho*, *colorado*, *manitoba*, *assiniboia*, *yosemite*, and possibly *oregonia*. I am reluctant to name additional members of the complex without abundant material showing sufficiently conspicuous superficial characters to assure their validity beyond reasonable doubt, hence several are being held for additional specimens. The species described below fulfills these conditions.

Hesperia hulbirti new species

Male.—Although variable, like all members of the genus, the upper surface of most specimens in the type series is very dark, the usual spots appearing reddish fulvous against a brownish black ground. In all specimens the band on the primaries terminates in an ill-defined shade beyond the stigma and behind Cu_2. In the cell and along the costa is a diffuse fulvous band which extends as far as the subapical spots in paler specimens. The outer row of spots on the secondaries is similar, distinct opposite the cell but fading out toward each end. One spot appears in the cell and usually a diffuse shade beyond. In paler specimens this shade expands to connect all spots, although they remain evident.

On the under surface the disk and costa are reddish fulvous marked with black at the stigma. Outwardly and behind the anal vein this area fades into a blackish diffuse zone, cut by pale veins. The apex has a heavy golden to greenish golden overscaling in which the three subapical spots and two beyond the cell stand out clear and pale, of a yellowish to pale fulvous shade. The secondaries have similar overscaling and a fine dark terminal line. The band of spots and the basal spots resemble those of the primaries in color, never clear white. In most specimens the band is made up of rather large spots with the exception of that before the radial, which is small to absent. With this exception no spots of the band are totally lacking in any of the types. The two beyond the cell tend to merge with the caudal three to form a continuous band in a few paratypes.

Female.—Upper surface as in the male, very dark, all spots tinged with fulvous in most specimens, but the preapical spots and those beyond the cell paler in some. The markings of the cell vary from a

small dot near the base of Cu_1 to a broad shade filling the cell except at its base. Secondaries as in the male but darker.

On the under surface the general pattern resembles the male but the spots are larger and pure white. The overscaling is of a more grayish green shade with the dark ground color showing enough to produce a slightly shaggy effect. The spot anterior to vein R in the outer band is not lacking in any of the types, and is large in most of them. A fine dark terminal line and dark dots extending into the pale fringes at the ends of the veins appear in most specimens.

Expanse: Male, 25 to 27 mm.; female, 28 to 31 mm.

The type series was captured on July 21, 1938, on Hurricane Hill in the Olympic Mts., Washington, by Mr. Lowell Hulbirt, for whom I take pleasure in naming the species. The *holotype* male and *allotype* female are being placed in the Carnegie Museum, Pittsburgh, Pa., and one pair of *paratypes* each is being sent to the Museum of Natural History in London and to the American Museum of Natural History in New York. Nine male and seven female paratypes are in the possession of Mr. Hulbirt, five pairs are in the Los Angeles Museum, and six pairs remain for the present in the collection of the author.

Descriptions in this group are of little value, for details of variation are usually repeated in several species. The tendency of variation in any species, however, is usually distinctive, and in comparison with other species the general habitus is usually characteristic when once a good series has been studied. This species is nearest to *manitoba*, which differs in the following points, based on a series of 17 males and 15 females, chiefly from British Columbia and Arizona.

1. *Hulbirti* is smaller, *manitoba* males varying from 28 to 33 mm. and females from 31 to 35 mm.
2. The spots of the under surface are clear white in both sexes of *manitoba*, contrasting sharply with the over-scaling. Only in males with greatly reduced spots are they faintly tinged with yellow.
3. In males of *manitoba* there is a prevailing tendency for the anterior spot of the band on the under side of the secondaries to be very small or altogether lacking, and for the two opposite the cell to be small and irregular, In the female the anterior spot is noticeably small in all but one specimen of the series at hand.
4. Although a dark species, *manitoba* is generally paler than *hulbirti*. This cannot be said of eastern specimens referred to *manitoba*. In these other differences prevail, but locality alone should prevent confusion.

VARIATIONS OF INSECT GENITALIA

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The employment of differences in the genitalic structure of male insects for the separation of otherwise similar species has been a very useful expedient in taxonomy for many years. It has been rather limited in some groups, but has become an essential part of classification in such difficult genera as *Erynnis* (*Thanaos* Auct.) of the order Lepidoptera, where the specific distinctness and the asymmetry of male genitalia were noted as early as 1870 by Scudder and Burgess (1).

The writer's evaluation of genitalia as specific characters was conditioned many years ago when a friend, expert in the classification of the Lepidoptera, sorted and labelled his slides in this genus. Two species, *persius* and *lucilius*, were indicated on these labels, although diligent search of the food plant failed to demonstrate the occurrence of the latter in the area where all of the specimens were taken, and it now seems probable that the former does not occur! The two species and a third, *afranius*, of the western states have similar genitalia, although they are quite distinct in the larval stage and live on different food plants, as was shown partly by Scudder (2) and partly by the writer (3). Forbes (4) has since added a species to this group and has ably summarized the characters of the known species, including those of the genitalia. The distinctions noted in these structures are far less striking than those that are evident among the other known species of the genus. Here the separation of species by genitalic characters, if it should prove to be feasible, must depend at least partly on quantitative differences. Such procedure, in the present state of our knowledge, is uncertain even in a genus where the use of genitalia in taxonomy has been necessary and dependable. These conditions can justify only one conclusion, that genitalic structure is merely another of the many criteria to which the taxonomist must resort, and that it must, like the others, be of variable practical utility.

Recently the writer has taken up another of the difficult genera of Lepidoptera for detailed study. In this genus (*Hesperia* Fab., very commonly known as *Pamphila* or *Erynnis*)

a number of species have been established on a basis of dependable superficial and genitalic characters, while a number of other names have been listed either as varieties of the European *comma*, as distinct species, or as probable synonyms. There is no accepted basis of classification for these doubtful forms, which constitute a large part of the material usually taken in the western states. Examination of the genitalia of some of these western insects has shown that if they are to be of any taxonomic value whatever some concept of their variability must be established. With the usual procedure of mounting few genitalia from a series of apparently conspecific specimens, the identity of distinctly different forms may easily be established. Elsewhere a more precise study seems needed, and this need has led to the present paper as a preliminary investigation.

VARIATION IN PYRGUS COMMUNIS

For this study the common checkered skipper, *Pyrgus communis* Grote, has been used, solely because of the availability of a long series of reared specimens, most of them closely related. The genitalia of 100 males were mounted on microscope slides, projected at the same magnification, and measured from the magnified image in millimeters to provide data for statistical study. In order to eliminate the factor of general variation in the size of the insects, all of these measurements were corrected to conform to the mean size of the series. Although we are accustomed to record size in terms of spread of wing, this character, as indicated by the length of the forewing from base to apex, was found to be much less constant than the width of the head. The latter measurement varied from 3 mm. to 3.7 mm. with a mean of 3.45 mm. and a coefficient of variation of $3.78 \pm .18$, while the coefficient of variation of wing length was $5.77 \pm .27$.

The text figure is an outline of the valve or clasper and of the dorsal view of the uncus, indicating in Roman numerals the measurements on which the study of genitalic variation was based. The first three series of measurements (I, II and III) indicate the degree of development of projections on the margin of the valve. The distribution curves for these measurements were very irregular polymodal curves. Total development of the principal marginal process, of which I, II and III are subordinate details, is less variable (Measurement IV). The distribution curve for this measurement, like that for the width of the head, was very close to the normal variation curve.

In seeking a basic measurement indicative of the general variation of the total size of the insect, the uncus was first considered. A brief check showed that the conspicuous structures shown in the figure were not closely correlated with total size, however, so their length was incorporated in the study as a fifth variable. Since characters of the uncus are often significant in taxonomy, this item is important. The frequency curve of this measurement (V) was even closer to the normal than the others.

The coefficients of variation for the five genitalic details are as follows:

I.	Distal tooth	25.44 ± 1.22
II.	Proximal tooth	59.42 ± 2.86
III.	Width of lobe bearing the teeth	29.14 ± 1.4
IV.	Width of valve and distal tooth, expressing gross development of the entire marginal process	10.48 ± .49
V.	Length of uncinal structures	8.18 ± .39

This study must be regarded as no more than a very incomplete suggestion of facts that we should have for the evaluation of genitalic criteria in the more difficult genera of Lepidoptera. Where genitalia present very evident qualitative differences, such data are not needed, but where characters of color and pattern follow a uniform plan and genitalic structures likewise are without conspicuous qualitative differences, they may be essential. In the genus *Hesperia* it is necessary

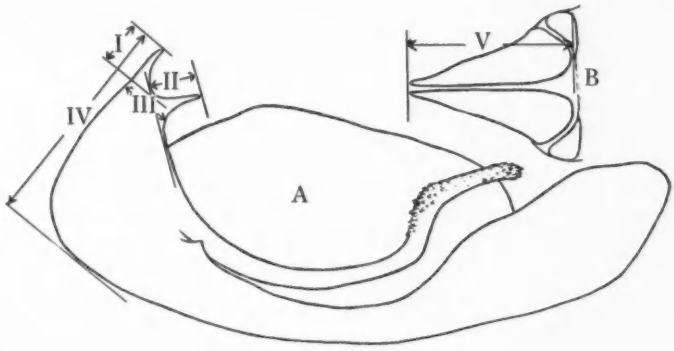

Fig. 1. Genitalia of *Pyrgus communis* Grote, male. A. Mesial aspect of right valve. B. Dorsal aspect of uncus. I to V, measurements referred to in the text.

to know whether the relative lengths of two marginal teeth are important, whether their spacing in relation to each other may be of taxonomic value, and whether the minor serration of the adjoining fold of the margin of the valve is significant between conspicuous presence and total absence. It will also be desirable to know whether the variability of these structures differs from that of the pattern of the wings, a point on which no light has yet been thrown.

Another question that arises inevitably in such problems concerns the dividing line between qualitative and quantitative differences. In the species considered in this paper it is quite true that the genitalia of *P. communis* seem always to be distinctive, although the western form, *occidentalis*, introduces an additional difficulty on which the writer has previously expressed an opinion (5). In spite of their distinctiveness, however, these structures occur in some individuals with the proximal tooth (II) completely lacking or with the long slender rod on

the mesial face of the valve of a modified form, presenting an appearance that might easily be taken as qualitatively different from the usual form. Moreover in the numerous European species of this genus more than one apparently valid species is distinguished by genitalic characters of a quantitative rather than qualitative nature. The difficulty is quite likely to be found wherever recourse to genitalia is necessary for the separation of superficially similar species.

CONCLUSIONS

The conclusions bearing on the taxonomic value of genitalia, as far as a single species may be significant, are these:

1. The quantitative variability of details of genitalic structure is greater than that of the size of the whole organism and probably as great as that of other characters of taxonomic value.

2. The development of the uncus is more nearly constant than that of any detail of structure of the claspers of the male genitalia, and its variability is more nearly normal.

3. Variability of subordinate structures of the claspers is so great and so erratic that these details must be used in taxonomy with great care.

These conclusions are quite in harmony with the limited observations thus far made in the study of *Hesperia*. Where differences appear in the uncus, they seem very dependable for the separation of species. Differences in the structure of the valves are in some cases conspicuous, but here greater variability reduces their value. In a group of western forms, possibly containing several species, it has been impossible as yet to find dependable genitalic characters. Here wing markings and genitalia alike display such a wide range of variation that it remains to be seen how the group can be arranged. Unfortunately few of these forms have been reared, so that adult characters alone are available for classification.

It is certain, in any case, that if the taxonomist finds superficially indistinguishable species marked by conspicuously different genitalia, as sometimes happens, he is dealing with a fortunate exception and not with a prevailing condition. The most difficult problems of this type cannot be solved by the simple expedient of making a few slides for comparison, but must await more extensive knowledge of the entire life cycle of the insect or a more penetrating evaluation of the characters available in museum specimens.

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PROTALLAGMA RUNTUNI N. SP. OF DRAGONFLY FROM ECUADOR WITH NOTES ON THE GENUS (Coenagriidae: Odonata)

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Columbus, Ohio

Protallagma runtuni n. sp.

Well over a thousand specimens of this little red and blue dragonfly have been sent up from the region about Baños, Prov. Tungurahua, Rep. del Ecuador by the collector, William Clarke-Macintyre, Esq. The largest series has come from Lake Runtún, which "is a small lake on the top of a hill overlooking Baños, near Mt. Tungurahua. The surface of the lake is about 2,000 meters elevation." I might add the high area about the lake is also called Runtún, and its elevation has been given variously as 2,000, 2,200 and 2,500 meters.

The localities and dates are as follows: Huira-Punga, Rio Pastaza, 1,500 meters, May, 1936, one envelope; Rio Pastaza (at Baños) and Baños, 1,820 meters, February to March, 1936, large series of several hundred; Panti-ucuchu, Rio Pastaza, May, 1936, small series; La Ventana, Rio Pastaza watershed, 2,000 meters, May, 1936; Tablon (in hills, north, across Rio Pastaza from Baños, 2,200 to 2,500 meters, May, 1936, one envelope; Runtún (see above) 2,200 meters to 2,500 meters, July 4, 1935, 25 envelopes, May 8, 1936, many envelopes, October 8, 1938, a few. A few specimens from equal elevations in Peru have been sent the Williamson Collection by Felix Woytkowski. I failed to get the exact data on these when they were offered.

The name *runtuni* = of Runtún, the lake of that name near Baños. This gives a name parallel with *titicacae*, that of the other species in the genus.

As Lake Runtún is the only lake in this whole region of vertical landscapes this species is probably a dweller in or near the more quiet reaches of turbulent mountain streams, or perhaps spring-fed rills. A good picture of the region about Baños is given in the article, "Mrs. Robinson Crusoe in Ecuador," by Mrs. Richard C. Gill, *National Geographic Magazine*, 65 (2): 133–172, 44 halftones (Feb., 1934).

The types are at present in the writer's collection. This species is a small, sturdy, hairy Zygopter with brown head and thorax and base of abdomen red, its apex sky blue. Male, abdomen 24 mm. long, hind wing 18 mm; female, abdomen 23 mm., hind wing 18.5 mm.

Holotype, male, color: The labrum, bases of mandibles, genae up to above level of bases of antennae, clypeus and frons a dull greenish yellow with more greenish in labrum, clypeus and frons than in the surrounding more yellowish parts. Vertex, post-ocular areas, dorsum and upper sides of thorax a medium reddish brown, which on the head between the ocelli is darker but which shades into a dull creamy color on the lower sides of the thorax. This creamy color then covers the ventral surfaces of the head and thorax, the coxae and legs, and the ventral surface of abdominal segments 1 and 2. Spines of legs black. Wings hyaline with brown veins and reddish brown stigmas.

Abdominal segments 1 to 6 red above and on the upper sides, shading into yellow on lower sides and on the sternal surfaces of segments 3 to 6. Segments 7 to 10 pale blue. The abdomen with major black areas as follows: the dorsal half of apical ring of segments 1 to 6; a dumb-bell-shaped spot saddled across the base of the apical fifth of segment 4 (slightly larger in holotype than in fig. 1); a similarly placed but larger spot across apex of segment 5, this spot connected with the apical half-ring; a similar spot on apex of segment 6 which has a broad lanceolate extension forward along the middorsal line to the first fifth of the segment. The blue segments, 7 to 10, each with a minute lateral apical black speck. A pair of black basal spots concealed under a fold of the intersegmental membrane between 9 and 10; apical dorsal edge of segment 10 black. Superior appendages black above, brown below; inferiors bluish on sides, yellowish above. Sternites of abdomen yellow except midventral keel on segments 3 and 4 narrowly edged with dark.

Structure, male: The insect is covered with light brown hairs on face, top of head, dorsal and lateral surfaces of thorax, coxae, femora and the lower surfaces of abdominal segments 1–3. The anterior edge of the frons rounded. The labium with a small, narrow midapical V-shaped notch. Distinct postocular impressions in the position of postocular spots when such are present in Coenagriid dragonflies. Prothorax (figs. 4 and 5) with an almost rectangular lobe on dorsal posterior edge. Mesostigmal lamina, simple, as in fig. 11: the spiracles protected by well developed ridges along the posterior side. Upper end of middorsal keel ending in a low tubercle (as is common in the Acanthagrion-Enallagma series of genera). A low, almost hemispherical

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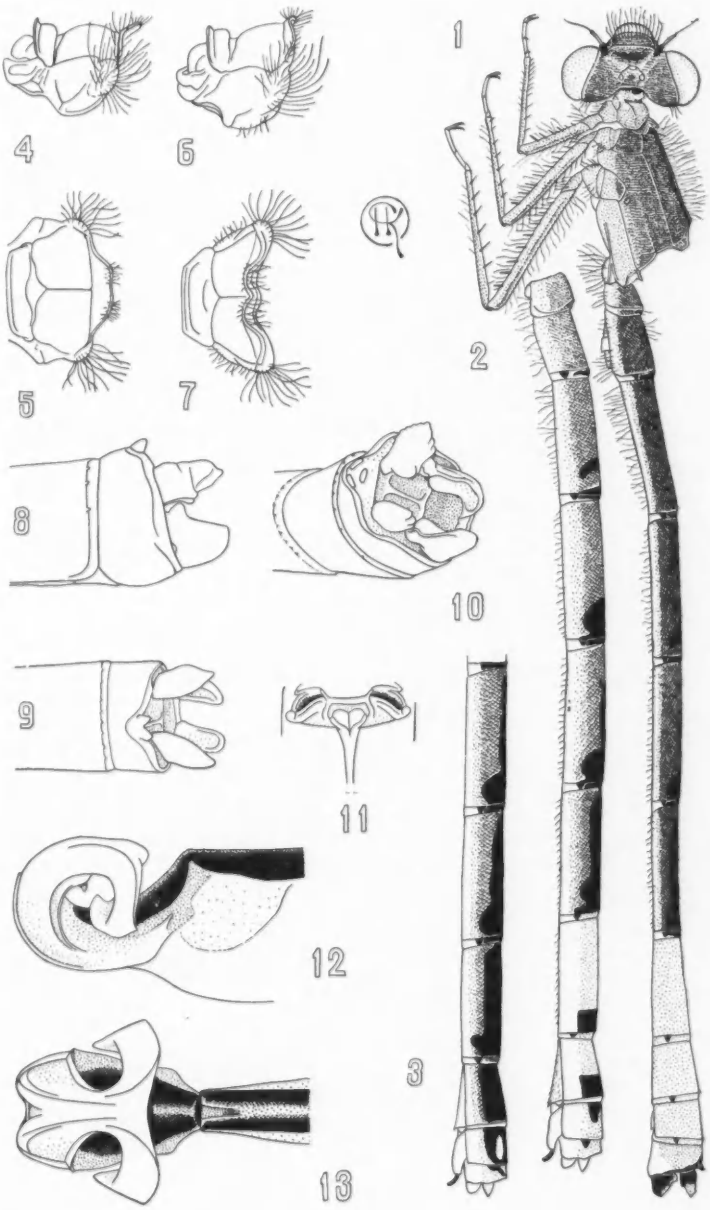
EXPLANATION OF FIGURES 1–13

Protallagma runtuni n. sp. Fig. 1. Male color pattern. 2 and 3. Female abdomens showing color pattern. 4 and 5. Male prothorax. 6 and 7. Female prothorax. 8–10. Male appendages. 11. Male mesostigmal lamina (similar in female). 12 and 13. Penis. Drawings from paratypes, Runtún, Baños, Prov. Tungurahua, Rep. del Ecuador.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hairy area on the ventral surface of thorax in front of sternum of abdominal segment 1. Spines of legs well developed, their length equal to the interspaces. Apex of hind femur reaching to middle of abdominal segment 2.

Abdomen rather heavy, increasing regularly in size from apex of segment 6 to apex of 9. Penis (described from a paratype, figs. 12–13) with no shaft hairs, no distinct internal fold and with a mere ridge in place of a posterior flap. Terminal segment with broad lateral lobes, their apices turned dorsad and internally a minute, sclerotized point (fig. 12). Apex of segment 10 very slightly elevated (figs. 8–10), with a pair of minute tubercles just within the upper edge. Below these a minute supra-anal tubercle.

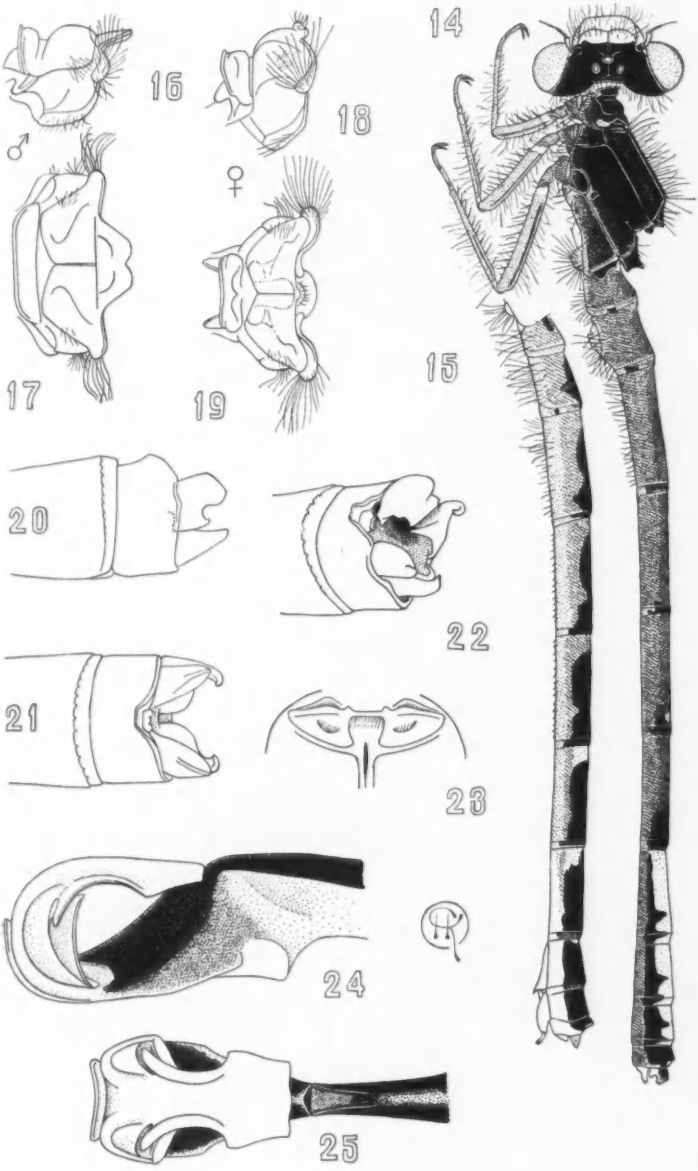
Superior appendages (figs. 8–10) from the side are mitten-shaped, with the short thumb pointing down at about midlength. This "thumb" is almost too short to deserve the term. In this type of appendage, in side view, the palm of the mitten faces towards the observer. The thumb (and its base) instead of pointing up is folded down outside of and across the palm with the tip of the thumb pointing down off the lower edge of the appendage. Entad of the thumb is a second projection off the lower edge of the palm (fig. 8). This "palm spine" is black and sharper-edged than the outer "thumb."

The inferior appendages, from the side view, are slightly deeper than the superiors but are subequal with the superiors in length and both equal in length to segment 10 along middle of its side: the inferior appendages are concave on the ental face (figs. 9 and 10) and each has a distinct basal thumb on the dorsal edge (in side view) the tip of which lies cephalad of the ventral thumb of the superior of that side.

Wings. (Described from a paratype male.) Coenagriid with 11 postnodals in fore wing and 9 in hind wing; stigma small, subtending less than length of the M_1 cell below it, oblique, the outer side more oblique than the inner side. Costa very slightly indented at stigma; 4 or 5 costal poststigmal cells. M_2 arising at level of postnodal 6 in fore wing and at 5 in hind wing. M_{1a} arising four cells farther out than M_2. Rs arises at subnodus, M_s close behind subnodus, thus enclosing a cell so narrow that its dorsal (M_{1+2}) side is shortest. Three M_4 postquadrangular cells. Arculus at antenodal 2, its upper or M segment twice as long as its M_4 segment. Quadrangle of fore wing narrower than that of hind wing, its depth 1.3 times in depth of quadrangle of hind wing; in fore wing anterior and inner sides equal, inner side 4 times in posterior side; in hind wing inner side 1.75 times in anterior side, the inner side 4 times in posterior side. Fore wing petioled (fig. 26) to Ac; hind wing to just before Ac.

EXPLANATION OF FIGURES 14–25

Protallagma titicacae (Calvert). Fig. 14. Male color pattern. 15. Female color pattern. 16 and 17. Male prothorax. 18 and 19. Female prothorax. 20–22. Male appendages. 23. Male mesostigmal lamina (similar in female). 24 and 25. Penis. Drawings from material collected by Felix Woytkowski, vicinity of Conception, Peru, Andes, 3,260 meters, April 13–15, 1935. In Williamson Collection, University of Michigan.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Described from holotype male, Runtún, Baños, July 4, 1935, collected by William Clarke-Macintyre, Esq.

Allotype, female, color: Color of head, thorax and thoracic appendages as in the male.

Abdomen colored as in the male except segments 5 to 10 are blue while the apical dorsal black spots on segments 4–6 are slightly more extensive. Segments 7 and 8 each with an apical black band 0.2 as long as 7 and 0.3 as long as segment 8. This dorsal apical band ending with a square end on middle of side. Segments 9 and 10 each with a pair of dorsal, basal spots, half as long as the segment. Appendages pale. (Segments 7–10 dark in some females, fig. 3.)

Structure. Head and thorax as in male. Wings as in male: 1 or 2 more costal cells beyond stigma than in the male wing. M_3 arises farther basally in female: the triangle formed between its base and the base of Rs has the outer or Rs side the shortest. Segment 8 with a minute ventral apical tooth on the sternite. Apex of ovipositor sheath (base of stylus) reaching base of apical third of segment 10. Styli heavy, their apices on level with apices of paraprocts. (See paratype female, figs. 2, 3, 6 and 7.)

Described from the allotype female, Rio Pastaza, March 30, 1936. (In envelope with a paratype male.)

Paratype material.—This consists of over 1,000 males and females from the region of Baños, Prov. Tungurahua, Rep. del Ecuador.

These are so nearly identical with the holotype and allotype in thoracic color and in appendages that description of these parts is needless. The wings vary in petiolation as much as is shown in the fore wing, fig. 26, and the fore wing, fig. 27. The origin of M_2 may be on a level between postnodals 6 and 7 in the fore wing and between 4 and 5 or beyond 5 in the hind wing.

The greatest variation is in the colors of the abdomen of the female. The ground color of segments 1 and 2 is red, usually segment 3 is red but segment 4 is red in an occasional female. The ground color of subsequent segments is blue. The extremes of black pattern on the female abdomen are shown in figs. 2 and 3. The process of drying has loosened pigment of head and thorax surfaces in some specimens so that there may be a fairly intricate light and dark brown pattern, nearly bilaterally

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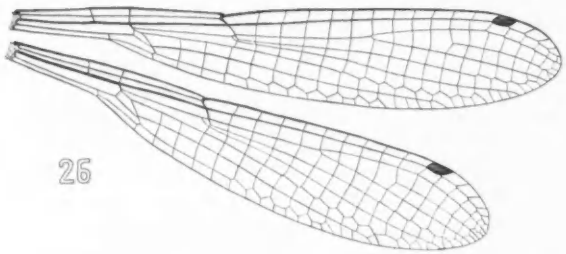
EXPLANATION OF FIGURES 26–29

Protallagma runtuni n. sp. 26. Wings of male. 27. Wings of female. Paratypes, Runtún, Baños.

Protallagma titicacae (Calv.). 28. Wings of male. 29. Wings of female. Conception, Peru, 1935.



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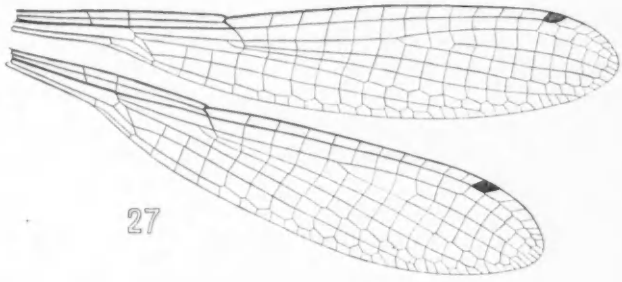

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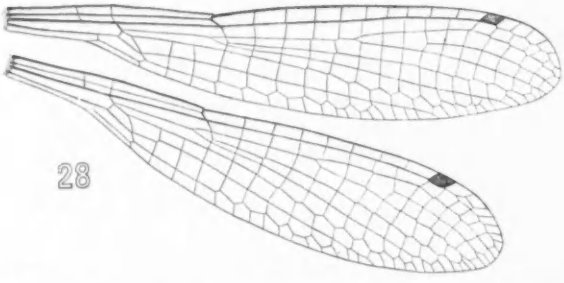

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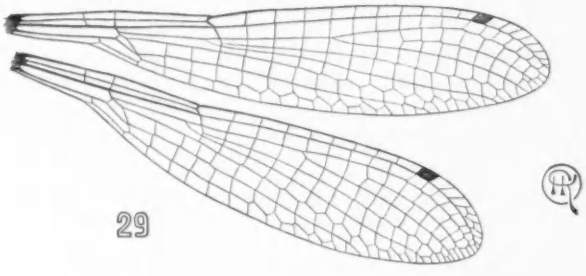

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symmetrical, on the head or on the dorsum and sides of the thorax, a pattern definitely due to drying.

Relationships.—The nearest relative of *runtuni* appears to be *Protallagma titicacae* Calvert.[1] We have made a detailed study of *titicacae* (Pl. II, figs. 14–25, and Pl. III, figs. 28 and 29). The venations of the two are practically identical. The red coloration is similar except of the latter the face is pale, and top of head and thorax are black while on the abdomen there is a black stripe along the sides of segments 7–9 with 10 wholly black. In the single female of *titicacae* examined the black is as extensive (fig. 15) as in the darker female of *runtuni* (fig. 3). Both species are equally hairy, nearly the same size, heavy bodied with rounded frons. The penes (*runtuni*, figs. 12 and 13, *titicacae*, figs. 24 and 25) are no more different than this organ is from species to species in Enallagma or in Acanthagrion (Kennedy, 1916, pl.), which are near relatives. Both species have the mitten type of superior appendage (seen from the side). In *titicacae* the "thumb" or downward projecting lobe is rectangular (fig. 20) and its width half as long as the appendage.

THE GENUS PROTALLAGMA KENNEDY

The discovery of a second dragonfly species closely related to *titicacae* and in the same high Andean zone warrants some notes on the genus *Protallagma* Kennedy. In my very brief description (Kennedy, 1920, p. 86) I noted its relationship by the type species *titicacae* to Enallagma, having in mind the North American blue and black forms of this genus. This was based on the mitten-shaped superior appendages and penis of the male. Its red color separated it from these Enallagmas. In the original description I mentioned also the lack of two tubercles on the apex of segment 10 in the male. This item needs correction as such exist in *runtuni* n. sp. The sturdy build and hairiness also separate the two species from Enallagma just as they also (with the red color) simulate Amphiagrion. We consider red color, hairiness and sturdy build as less fundamental characters than the structure of the male appendages.

The mitten-shaped appendage is a type found in the blue and black Enallagmas (*carunculatum*, *civile*, more obscured in *hageni*, *annexum boreale*, etc.). In Enallagma the palm faces

[1] I wish to thank F. M. Gaige and Mrs. Leonora K. Gloyd for loan of material of *titicacae* from the Williamson Collection.

out but the thumb points up or caudad. (In such species as *basidens*, *aspersum*, etc., the lower fork is smaller than the upper fork or thumb which reverses the relationship of the two parts.)

The superiors of *runtuni* differ from any North American Enallagma appendage in that there is a second or "palm spine" on the inner lower edge of the superior appendage. The only similar appendage is that of *Archaeallagma ovigerum* (Calvert) which has a greatly developed inner "palm spine." Apparently, then, *runtuni* has some relationship closer to *ovigerum* than to North American Enallagmas.

During Christmas week, 1938, the writer made a trip from New York to Boston to study the type of *Enallagma ovigerum* Calvert in the Museum of Comparative Zoology. This curious species has the size, lack of hairiness, blue and black color, venation of wings and mitten-appendages of northern Enallagmas, but it is unique among American Enallagmas in having the large inferior spine on the superior appendage and in having a distinct apical crest on abdominal segment 10 as in Ischnura. A careful study of the superior appendage of *runtuni* shows homologous parts. The penis of *ovigerum* has never been studied. The type is in such poor shape no attempt was made to study it, if it still exists in the bristled specimen. Thus *ovigerum* can be cast in with other blue and black North American Enallagmas or can be given the generic name Archaeallagma (Kennedy, 1920, p. 87) because of its appendages, unique among species of Enallagma. (Ris, 1916 (1918), describes the female *ovigerum*.)

Titicacae Calvert was placed in Amphiagrion by Calvert which till then contained only North American species. I cannot see this placement as the superior appendages of the North American Amphiagrions slope downward to meet the apices of the horizontal inferiors as in the appendages of Acanthagrion. By this evidence the closest relatives of North American Amphiagrions are South American Acanthagrion, some Oxyagrions and Central American Anisagrion. The penes of North American Amphiagrions fit well among the diverse forms found in Acanthagrion (Kennedy, 1916, pl.).

The venation is not dependable for generic characters within the group of genera composed of Enallagma (North Amer. spp.), Amphiagrion (North Amer. spp.), Acanthagrion, Oxyagrion, Cyanallagma Kennedy, 1920, Protallagma, and

Archaeallagma (*En. ovigerum* Calv.). If this group is broken into genera they will have to be separated on color characters, hairiness, type of male appendages, penis characters and stature, as well as geographic distribution. Notice the venational variations in figs. 26 to 29.

WORKS DEALING WITH AMERICAN GENERA RELATED TO PROTALLAGMA

Byers, C. F., 1927. Key to the North American species of Enallagma with description of a new species (Odonata: Zygoptera). Trans. Amer. Ent. Soc. 53: 249–260, 3 figs. (Keys, bibliography, and desc. of *En. culicinorum.*)

Byers, C. F., 1927. Enallagma and Telagrion from western Florida, with a description of a new species. Ann. Ent. Soc. Amer. 20: 385–392, 9 figs. (Desc. of *En. weewa* with notes on seventeen species.)

Calvert, P. P., 1895. The Odonata of Baja California. Proc. Cal. Acad. Sci. Ser. 2, 4: 463–558, 3 pls. (Desc. *En. eiseni.*)

Calvert, P. P., 1901–1908. Odonata. Biologia Centrali Americana, Introd. and pp. 17–420 of vol. "Neuroptera," 9 pls., 1 map. (Desc. *En. basidens.*)

Calvert, P. P., 1903. Additions to the Odonata of New Jersey, with descriptions of two new species. Ent. News 14: 33–42, 1 pl. (Desc. *Telagrion daeckii.* See Kennedy, 1920, p. 87, Telleallagma, and Byers, 1927, pp. 389–392.)

Calvert, P. P., 1909. Contributions to a knowledge of the Odonata of the Neotropical Region, exclusive of Mexico and Central America. Ann. Carnegie Mus. 6: 73–280, 9 pls. (Describes *Amphiagrion titicacae* and *Enallagma ovigerum,* Oxyagrion and Acanthagrion well treated, also Skiallagma Förster and Tigriagrion n. gen.).

Calvert, P. P., 1919. Gundlach's work on the Odonata of Cuba; a critical study. Trans. Amer. Ent. Soc. 45: 335–396, 3 pls. (An elaborate discussion of the group in Enallagma composed of *truncatum, pollutum, vesperum, signatum, pictum* and *laurenti* n. sp.).

Charpentier, T. de, 1840. Libellulinae Europaeae Descriptae ac Depictae. 180 pp., 48 pls. (Page 21 defines Enallagma.)

Davis, Wm. T., 1913. Dragonflies of the vicinity of New York City with a description of a new species. Jour. N. Y. Ent. Soc. 21: 11–29, 2 figs. (Desc. *En. recurvatum.*)

Förster, F., 1906. Neotropische Libellen. III. "Insekten-Börse" 23: 1–5 (reprint.) (Skiallagma n. gen. desc., near Acanthagrion. See Calvert, 1909, pp. 176–178.)

Förster, F., 1909. Beiträge zu den Gattungen und Arten der Libellen. Wiesbaden Jahrb. Nassauischen Vereins für Naturk. 60: 211–235. (Describes *Amphiagrion andinum.* Förster's types in the Williamson Collection are *Amphiagrion titicacae* Calvert.)

Förster, F., 1914. Beiträge zu den Gattungen und Arten der Libellen. III. Archiv. für Naturgesch. 80, Abt. A., Heft 2, pp. 59–83. (Desc. Myagrion n. gen. which by sloping superior appendages is an Acanthagrion or near that genus.)

Gundlach, Juan, 1886. Contribucion a la entomologia Cubana, Tomo II, Parte Tercera. Neuropteros, pp. 189–281+V. [Notes on *En. coecum, En. cultellatum* (Neoerythromma Kennedy, 1920), *En. truncatum, En. civile, En. doubledayi, En. aduncum* (=Argiallagma Selys, 1876)].

Kellicott, D. S., 1895. Odonata—A note and a description. Ent. News 6: 239–240. (Desc. *En. geminata.*)

Kellicott, D. S., 1895. Catalogue of the Odonata of Ohio. Part I. Jour. Cincinnati Soc. Nat. Hist. 18: 195–216. [Desc. *En. fischeri, =antennatum* (Say)].

Kennedy, C. H., 1916. Notes on the penes of Zygoptera (Odonata). 1. Species limits in the genus Acanthagrion. Ent. News 27: 325–330, 1 pl. (The types of penes found in Acanthagrion.)

Kennedy, C. H., 1917. Notes on the life history and ecology of the dragonflies (Odonata) of central California and Nevada. Proc. U. S. Nat. Mus. 52: 483–635, 403 figs. (Description of Zoniagrion which lies close to the genera discussed.)

Kennedy, C. H., 1920. Forty-two hitherto unrecognized genera and subgenera of Zygoptera. Ohio Jour. Sci. 21 (2): 83–88. (Describes seven genera related to Enallagma and Acanthagrion.)

Kirby, W. F., 1890. A synonymic catalogue of Neuroptera Odonata. London. Pp. ix and 202. (Synopsis of literature to 1890.)

Morse, A. P., 1895. New North American Odonata. Psyche 7: 207–211. (Desc. *En. minusculum, En. calverti, En. carunculatum, En. clausum.*)

Morse, A. P., 1895. New North American Odonata. II. Psyche 7: 274–275. (Desc. *En. laterale* and *En. pictum.*)

Munz, P. A., 1919. A venational study of the Suborder Zygoptera. Mem. No. 3. Amer. Ent. Soc. Pp. 1–78, 20 pls. (Keys to genera.)

Muttkowski, R. A., 1910. Catalogue of the Odonata of North America. Bull. Publ. Mus. Milwaukee, Vol. I, Art. I, pp. 1–207.

Needham, J. G. and **H. B. Heywood,** 1929. A handbook of the dragonflies of North America. Pp. viii and 378, figs. (Treatment of Enallagma, Amphiagrion, etc., with assistance of C. F. Byers.)

Ris, F., 1908. Odonata. From: "L. Schultze, Forschungsreise im westlichen und zentralen Südafrika ausgeführt in den Jahren 1903–1905." Denkschr. med.-nat. Gesellsch. 13: 303–346, 17 figs. (Review of African Enallagmas. See also Kennedy, 1920, p. 87, Africallagma.)

Ris, F., 1916 (1918). Libellen (Odonata) aus der Region der amerikanischen Kordilleren von Costarica bis Catamarca. Archiv für Naturgesch. 82, Abt. A. Heft 9, pp. 1–197, figs. 1–117. (Notes on *En. ovigerum* Calv., desc. female: desc. *En. occultum.* See Kennedy, 1920, p. 87, Mesamphagrion. Acanthagrions and Oxyagrions described.)

Ris, F., 1921. The Odonata or Dragonflies of South Africa. Ann. South African Mus. 18: 245–452, 8 pls., 77 text figs. (Nine African Enallagmas.)

Root, F. M., 1923. Notes on Zygoptera (Odonata) from Maryland, with a description of *Enallagma pallidum*, n. sp. Ent. News 34: 200–204, 2 figs.

Root, F. M., 1924. Notes on Dragonflies (Odonata) from Lee County, Georgia, with a description of *Enallagma dubium*, new species. Ent. News 35: 317–324. 4 figs.

Selys, Edm. de, 1876. Synopsis des Agrionines, 5me légion: Agrion (suite). Bull. Acad. roy. Belg. (2) 41: 1–282 (reprint). (Amphiagrion, Oxyagrion, Acanthagrion and Enallagma.)

Williamson, E. B., 1900. Notes on a few Wyoming dragonflies. Ent. News 11: 453–458, 1 pl. (Desc. *En. anna.*)

Williamson, E. B., 1900. The dragonflies of Indiana. Twenty-fourth Ann. Rept., Dept. Geol. and Nat. Resources of Indiana for 1899, pp. 229–333, 1003–1011, 7 pls. (Desc. *En. piscinarium.*)

Williamson, E. B., 1922. Enallagmas Collected in Florida and South Carolina by Jesse H. Williamson with descriptions of two new species (Odonata: Agrionidae). Ent. News 33: 114–118, 138–144, 1 pl. (Desc. *En. sulcatum* and *En. concisum.*)

Williamson, E. B., and **J. H. Williamson,** 1924. A remarkable new genus of Coenagrionidae from Brazil, with descriptions of three new species (Odonata). Occ. Papers Mus. Zool. Univ. Mich. No. 154, pp. 1–24, 1 pl. (Desc. Acanthallagma with three n. spp. related to Acanthagrion.)

ANIMAL ECOLOGY, by A. S. Pearse, Second Edition. 1939. Pp. xii and 642, 133 figs., 6 x 9 inches. Published by McGraw-Hill Book Co., Inc., 330 West 42nd St., New York, N. Y. Price $5.50.

This is a complete revision and an expansion of the first edition published in 1926. It is so thoroughly documented that, besides being an organization of the science of animal ecology, it constitutes a review of the literature praticularly that on ecology of the Americas.

We have always enjoyed Professor Pearse's point of view and his approach to his subject. His mind deals with the broadest aspects of life. He neither shifts along from one biological "latest fad" to the next, nor does he over-emphasize any personal theory. In ecology he has never become lost in the semi-dessert of soils and climates but still studies animals. Because we have to have animals in animal

ecology we enjoy his various works which, with so little bias, summarize what is known of animal life.

We can carry this comment on point of view and type of study a paragraph farther. The botanical phases of ecology have advanced so much more rapidly than have the zoological, perhaps because plants are both more obvious and more stationary, that the greater part of ecological literature is heavily over-balanced toward factors that more specifically relate plants to the environment. On all sides the discussion concerns an environment which is analyzed into factors of soil, of air, of water and of sunshine. The plants and even more so, the animals, move across this physical stage as dummies which have too little concern with each other. This is a criticism of no specific school of thought. It is a condition stemming from the stage of development of the science, and due, directly, to the inadequacies of all human thinking. This condition appears to come from the fact that animal ecology is in its infancy; in fact it is almost embryonic. Associated with this youth of a physiological science is the accurate measurement of those factors which are measured most easily. Man can measure and correlate physical much more readily than he can biological factors. Hence physical factors tend to be studied first. Back of this is the fact that man has to succeed to keep up courage. Biological factors, because of their greater complexity, are baffling and discouraging to all but master minds. We feel that this human necessity of a modicum of immediate success has been one of the factors which has held back a broader knowledge of biotic interrelationships. We have always felt that Pearse was too much interested in life itself to ever recognize a condition of bafflement, let alone one of defeat.

But back to our muttons, our cellulose and printer's ink! "Seven new chapters have been added to this edition. The new chapters include information on climate, evolution, chorology, succession, climaxes, rhythms, communities, competition, populations, teaching ecological problems and economic ecology." With such a mine of condensed information we can point out only a few of the high points and these unfortunately will probably be chosen according to the prejudices of the reviewer.

Rhythms. For some years the writer watched for published matter on biological rhythms, enough to make one lecture in a course on the biology of insects. Eventually, because of lack of success, the effort was discontinued. In this volume we find a chapter of forty pages which includes much interesting and pertinent matter. In our present knowledge of rhythms, it is mostly descriptive. However, biological rhythms as a factor in adaptation, internal and external, have received more notice than in the past. We believe it is to the advantage of the science.

The chapter on economic ecology merely outlines the vast field which figures into all phases of our basic industry of agriculture. It is only lightly documented.

A chapter on teaching ecology sketches the many lines of work which can bring the student into direct contact with the relationships of plants and animals to the environment. Being from Pearse and on ecology, it naturally emphasizes field work over all else, six lines on lectures and six pages on field work.

The chapter on problems in ecology will help the inquisitive mind which lacks originality and the analytical ability to recognize the problems to be found on all sides.

One thing still is lacking which is omitted in all ecologies to date. We might state the problem thus: Man and a few other animals live in societies characterized by co-operation and certain unselfish behavior. These societies, of man, of the honey bee, etc., are immersed in a world of individualistic Metazoa with largely selfish behavior. Both levels of animal life, that of the society and that next below, of selfish Metazoa, are immersed in a larger and interpenetrating world of Protista with very different relations to the environment. The interrelationships of these and the relationships of each to the physical environment have never been adequately outlined philosophically. Eventually we will find chapters in ecologies on these broad problems. The problems must exist, because nature herself has erected each on the next lower as a type probably more adaptable to the immediate (in time) environment.

We have enjoyed this volume, and besides the usefulness of its broad point of view, we believe that its extensive and careful documentation will make it a key to the literature. At every opportunity we have voted that any general review of a subject should have extensive and careful documentation.—C. H. K.

INVESTIGATIONS ON THE RESISTANCE OF MEALYBUGS (HOMOPTERA) TO PARASITIZATION BY INTERNAL HYMENOPTEROUS PARASITES, WITH SPECIAL REFERENCE TO PHAGOCYTOSIS

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The resistance or immunity of insects to invading organisms is an accepted phenomenon about which comparatively little is known. However, investigations regarding the use of beneficial insects in combatting insect pests have accentuated the need for further knowledge of it.

The object of the investigations reported on in this paper was to determine the degree of resistance of the different host species studied, when the destroyed parasites die, and as much as possible about the relation of phagocytosis, if any, to the resistance of the hosts. Several thousands of parasites and parasitized mealybugs were studied intensively during these investigations. These studies were made during the fiscal year of 1935–36.

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ACKNOWLEDGMENTS

These investigations were made possible through a fellowship extended to me by the National Research Council and through the facilities and co-operation of the University of California. I wish to express my sincere appreciation and thanks to Prof. Harry S. Smith, under whose supervision the work was done. He suggested the material to use and started cultures of the different species for me previous to my arrival at Riverside, California, where the studies were made. His interest in the problem and valuable advice contributed frequently and freely were invaluable to the work. I am also indebted to Mr. J. D. Maple for the identification of some skins of mealybugs from which adult parasites were reared; to Mr. Harold Compere, Mr. Charles Persing, Dr. S. E. Flanders, Dr. L. J. Klotz and Dr. W. D. Sinclair for valuable advice.

REVIEW OF LITERATURE

The conclusions of past observers vary considerably as to the causes for the immunity of insects to certain invading parasites. A resumé of some of their observations and conclusions are given below.

In the latter part of the last century Metchnikoff, Cuenot, Levaditi and others, noted cellular reactions (phagocytosis) in insects in response to the introduction of certain parasites and foreign particles, and they considered these reactions as important factors in immunity.

Marchal (1906) in his splendid paper on the biology and development of certain hymenopterous parasites discusses the response of the hosts to attack by parasites. The reactions associated with the development of *Trichacis remulus* Walker, a parasite of Cecidomyiid larvae, are extremely interesting. The parasite eggs are deposited within the nerve cord of the host. As the egg increases in size, it is pushed toward the exterior and finally expelled outside the nervous tissue; but is always stopped by the conjuctive envelope of the nerve cord, and remains between this envelope and the nervous tissue, so that, throughout its development, it remains in the form of a cyst suspended to the nerve cord. The cells of the nervous system itself are modified, and the development of certain nuclei becomes pronounced. However, the principal reactions occur within the cells of the outer wall of the cyst formed from the conjunctive envelope of the nervous system. The cells of this membrane, which, in the normal state, are very small and flat, are distended and their nuclei become greatly enlarged. The cells which form the cyst around the parasite egg are considered to be true giant cells. He states that in the early stages, these giant cells have a close resemblance to the amoebocytes, and may only have at that time a slight adherence with the cyst. Agglomerations of amoebocytes were observed around the tumors formed by the cysts along the nerve cord. In his opinion, it is legitimate to consider the cyst of giant cells which surround the parasite to be like an internal "animal gall," produced

under the influence of the host reaction to the excitation caused by the parasite. He considers their formation to be simply a result of the reciprocal reactions of the host and parasite, and as evidence that there is a struggle between the parasite and host elements. In a certain number of cases death of the parasite egg ensues from the struggle, but in the majority of the cases the parasite is victorious. Marchal discusses another parasite, *Inostemma piricola* Kieffer, which develops within cysts appended to the brain of Cecidomyiid larvae. The cells of the brain immediately surrounding the parasite do not multiply to any great extent, and giant cells are never formed around the parasite. The reactions produced are analogous to those caused by *Trichacis remulus* on the ventral nerve cord of its host, but the reactions are far less intense. Adventitious cysts formed around eggs of *Platygaster ornatus* Kieffer were studied by him but he was uncertain about their origin. One possible explanation offered is that the egg of the parasite is first engulfed by amoebocytes, but the egg is able to resist their attack, and as a result the surrounding cells are affected in such a way that they hypertrophy. In reference to *Platygaster* sp., Marchal states that the envelope or cyst which surrounds the egg is formed from amoebocytes or young conjunctive cells of the host which are grouped, in variable numbers, around the egg. These cells are fused and hypertrophied to form a thick envelope. In the early stages an egg might be found enclosed by a single cell, which suggested to him that where more than one nucleus are found within an envelope, they may have arisen from a unique primitive nucleus. However, he prefers to consider certain multinucleated envelopes as originating from an association of many cells around the eggs, rather than originating from a unique nucleus.

Timberlake (1912) found that *Limnerium validum* Cresson would oviposit into caterpillars of the brown-tail moth, gipsy moth and rusty vaporer moths in which it was unable to complete its development. He states that the larvae are unable to survive the protective reactions of the host, which are visibly manifested by an accumulation of active blood cells or amoebocytes around the eggs and larvae. In reference to the few individuals which were able to complete their development within the tent caterpillar, he suggests that the adaptation may be due to larval secretions which ward off the protective reactions of the host.

The eggs of certain hymenopterous parasites deposited within melon fly (*Bactrocera cucurbitae* Coquillett) larvae become encysted within a mass of transparent cellular material (Pemberton and Willard, 1918). At first the egg is only thinly surrounded with the encysting substance, but after two or three days it becomes densely enclosed. By this time the egg has collapsed slightly and has become brownish in color. The melon fly larva containing such encysted eggs continues its development uninterrupted, transforms into an adult fly and carries these eggs within its body, usually within the fat masses, until death. Although the melon fly larva is immune to the development of *Tetrastichus giffardianus* Silvestri, it was found by experimentation that these larvae could be made susceptible by subjecting them to parasitization by another parasite, *Opius fletcheri* Silvestri. In the host larvae in which both parasites oviposited, the larvae of *O. fletcheri* always died

while very young, and all of the larvae of *T. giffardianus* survived. It was concluded that the immunity of the melon fly larva against the development of *T. giffardianus* was destroyed at the time it received the egg of *O. fletcheri*. They attribute this weakened resistance to toxic substances injected into the host larva by the female of *O. fletcheri* during oviposition.[2]

Holland (1920) in his paper on the reactions of the tissues of *Dytiscus marginalis* L. to platyhelminthes larvae encysted and fixed to the wall of the digestive tube of the insect, discusses the formation of leucocytic agglomerations around such encysted larvae, and possible causes of their formation. Although the trematode larvae become encysted, apparently there is no appreciable detrimental effect on either the parasite or the host. The trematode larvae are chemotactically negative to the leucocytes as long as they receive the proper nutrition. They cease to grow as a result of the diminution of nutritive exchanges,[3] and no more substances repulsive to the phagocytes are produced. Therefore, at that time, the phagocytes are attracted toward the cyst, as they would be toward a strange body introduced into the blood of the insect. In addition, the attraction of the leucocytes may be activated at that time by the secretion of new special toxins by the cyst. The nutritive elements necessary to the life of the encysted larva must pass through the thick shell of amoebocytes which surround the cyst. On the other hand, the shell of living cells may check and neutralize in part, through the antitoxins produced by the leucocytes, the toxins secreted by the encysted larva. Later (1930) Holland described the formation of simple and compound leucocytic nodules in the blood of caterpillars injected with Koch bacilli. He found that micronucleocytes phagocytized the bacilli and then the macroneucleocytes in turn phagocytized, in a manner, the micronucleocytes. Macroneucleocytes may upon ingesting one or more microneucleocytes be unable to digest alone all of the phagocytized microbe bodies; whereupon, new macroneucleocytes intercede, and become united to the surface of the former. In this way simple leucocytic tubercular nodules are formed. Some of the simple leucocytic nodules, which form in contact with one another, may become secondarily enveloped by new macroneucleocytes attracted by their presence. Several simple nodules may become fused in a similar mass of macroneucleocytes and form a compound leucocytic nodule. He states that the leucocytic nodules

[2]It is doubtful whether this explanation for the cause of weakened resistance is correct in general. Fertilized (female) eggs of *Coccophagus gurneyi* Compere often succumb and are destroyed within certain mealybugs (*Pseudococcus citri* (Risso), *Ps. maritimus* Ehrh.), while infertile (male) eggs deposited within these hosts apparently develop normally. It appears that the resistance of the parasite, or weakened resistance of the host, is due in some way to chemical substances associated with the parasite egg or larva, rather than to toxic substances injected by the adult female at the time of oviposition. It seems too far fetched to assume that toxic substances are injected with either the fertile or the infertile egg, but not with both.

[3]Flanders (1938) makes a somewhat similar postulation, suggesting that starvation may be the cause of death of parasite larvae in immune hosts. Workers have demonstrated that the successful development of certain parasites in higher animals is dependent upon the diet of their hosts.

formed around tubercular bacilli in insects are not the product of a specific reaction with respect to Koch bacilli, but that such nodules are formed in the presence of all foreign bodies. His conclusions are that caterpillars are able to digest tubercular bacilli because the toxins of the microbes do not affect their leucocytes; and perhaps also because the bacilli have on their surface a covering liable to attack by the digestive juices of the caterpillars.

Wells (1925) states that "immunological reactions, the processes by which the living organism defends itself against the chemical attacks of its enemies and so is able to exist in an environment seething with such enemies, are chemical reactions. The reagents involved are substances endowed with active chemical properties, and they are the product of chemical activity of the tissues of the body." According to him, apparently an antibody can react with various related antigens (i. e., protein molecules), specificity being always a quantitative matter. Non-specific immunological reactions are thought to depend on the existence of identical proteins in different species, or different proteins with identical grouping. He suggests that the actual defense of the body against infection probably depends largely on the part played by the cells of the blood and tissues, and that their attraction to the point of infection is induced by the action of chemical substances produced by the infecting agent, or by the injured tissue.

Paillot (1923) observed that about 40 percent of the eggs of *Eulimneria crassifemur* Thomp. deposited within *Neurotoma nemoralis* L. became coated with a false membrane and died. This author (1928) found that a considerable proportion of the eggs of *Limnerium alkae* Ellinger and Sachtleben deposited within the body cavity of *Pyrausta nubilalis* Hb. larvae die and become surrounded by macroneucleocytes. The phagocytic action is considered to be the cause of the death of the eggs. He states that the death of supernumerary larvae of this parasite is not caused by the action of a cytolytic enzyme appearing in the blood of the host after the first parasite larva has hatched. He (1934) found that the giant cells formed within parasitized aphids are derived from the sex cells.

Spencer (1926) suggests that the phenomenon resulting in the death of supernumerary parasite larvae within parasitized aphids is that the first parasite larva arriving at the hatching stage molts and then begins to secrete a cytolytic or digestive enzyme, which frees it from its serosa, and brings about the degeneration of the larvae which hatch later on. He states that the aphid embryos in parasitized aphids degenerate in a similar manner.

Meyer (1926) discusses at some length the immunity of certain caterpillars to their ichneumonid parasites. In discussing the encapsulation of eggs of *Apanteles glomeratus* L. within *Pieris rapae* L. he states that the incipient development of the egg does not cease, but usually continues to the formation of the larva. The parasite egg is first surrounded by a small number of large haemocytes which are completely fused together. After a time the capsule enclosing the egg assumes the appearance of a hollow sphere whose wall is composed of two layers, the outer of a row of larger cells, and an inner one of flat spindle-form

cells. Eventually the lumen of the capsule disappears, the borders between the cells become indistinct, and the eggs of the parasite become enclosed within a fast syncytium. After several days the parasite eggs begin to dissolve and decompose into a number of small lumps that are scattered within the enclosing syncytium. Meyer considers the cyncytia to be similar to those described by Metalnokov in *Galleria* larvae after injecting into the body cavity foreign particles or certain pathological bacteria. Forty percent of the larvae of *P. rapae* were found to be immune in this way to *A. glomeratus*. An analogous phenomenon was observed within *P. rapae* larvae in response to parasitization by *Angitia rapae* Meyer. An egg was observed, only one end of which was enclosed by the blood cells of the host. Whereupon he concludes that enclosure begins on one of the pointed ends of the egg. At first the capsule appeared to be composed of several layers of round cells. Within a short time the cells of the inner layer begin to elongate and form a compact layer, while the outer layer remains loosely joined. Finally, the cells fuse together and form a syncytium that lies close to the egg which is gradually destroyed. About 27 percent of the larvae of *P. rapae* were immune to *Angitia rapae*. He considers that some caterpillars are immune to parasites because of the ability of their phagocytes to enclose the parasite eggs. He found that the ichneumonid parasite *Angitia fenestralis* Holmgr. normally refuses to oviposit within certain individuals of its host, *Plutella maculipennis* Curtis, and if these individuals which have been refused should be attacked, the parasite is unable to develop within them.[4] He lists other species which exhibit similar characteristics (Meyer, 1927). About 18 percent of the larvae of *Mamestra brassicae* parasitized by *Exetastes cinctipes* Ratz. developed into butterflies.

The rapid death of freshly hatched larvae of certain tachinids, *Gonia* spp., in noctuid larvae is considered by Strickland (1923, 1930), to be due in some manner to their enclosure in a phagocytic cyst. He states that at least it presented an impassable barrier against their essential passage to the supraeoesophageal ganglia. Eggs of the braconid *Meteorus vulgaris* Cress. deposited within immature noctuid larvae hatched and the larvae were not attacked by phagocytes, except in the event of their death; but the eggs deposited within larvae already contracting in preparation for pupation were surrounded by dense phagocytic cysts three days after deposition.

Brooks (1930) states that young larvae of *Rhyacionia buoliania* Schiff. recover from parasitization because of phagocytosis of the parasites' eggs and newly hatched larvae. He suggests that a parasite larva, the development of which has been delayed until the host has reached the pre-pupal stage, may be attacked by phagocytes, broken down, and the tissues built up into the tissues of the adult moth. Such retardation of the parasite larvae was often noted when super- or multiple-parasitization occurred, and he suggests that it probably

[4]My observations do not support this statement; but on the contrary, indicate that host specificity in oviposition exhibited by parasites is a phenomenon associated with the "attractiveness of the host" which is not necessarily an index to the resistance of the host to the development of the parasite.

results either in the recovery of the host from parasitism, or death of host and parasites from mutual exhaustion.

Thompson (1930 a) concludes that as a general rule the healthy larvae of entomophagus insects are not surrounded by phagocytes, provided that they lie free within the body cavity of the host. Regarding the accumulation of phagocytes around a parasite which has an anatomical relation with the host in such a way that destruction of the tissue results, he states that the extent to which phagocytes accumulate appears to depend in part upon the specific nature of the host, and in part upon its general condition, but that such an accumulation has no effect on healthy parasites. He (Thompson, 1930 b) considers that there is no support for the view that the adaptation of an internal insect parasite to its host consists essentially in the development of substances destined to repel, or in structures designed to afford protection from, phagocyte attack. In his opinion, there is no reason to suppose that the host pupal period is a dangerous one for internal parasites, or that they require protection to enable them to survive. He does not agree with the idea that substances from the tissues of phagocytized parasites are built up into the tissues of the host. He states (1934) that he is inclined to believe "that phagocytes do not in actual fact possess any inherent disposition to attack invaders, and that the latter, if in a healthy condition, do not require any anti-phagocytic substance to save them from a phagocytic onslaught, any more than do the tissues of the host itself." The behavior of the phagocytes is considered to be merely reactions to the presence of certain substances (pathological exudates) resulting from the degeneration of cells and tissues. It is suggested that possibly some eggs normally secrete a substance during their development which may immobilize the phagocytes. The possible explanation offered for the encystment of *Gonia* larvae as noted by Strickland (1923, 1930) is that it may be due to secretions and contents of intestinal cells with which the larvae have been covered in their passage through the gut to the body cavity.

Metalnikov (1932) considers that the immunity exhibited by insects to microbes is analogous to that possessed by higher animals. Immunity is realized because of the activity of different cells, some of which surround and digest microbes, and some produce antibodies. Therefore, immunity depends upon the energy and rapidity with which the cells act against microbes. He states that studies conducted with the *Galleria mellonella* L. caterpillar demonstrate that the destruction of the cerebral ganglia, and first two thoracic ganglia does not affect immunity. However, the destruction of the third thoracic ganglion rapidly diminishes natural and acquired immunity. Metalnikov considers that the principal cause of immunization and acquired immunity is the re-enforced sensitivity of the cells.

Eckstein (1932) in his paper on immunity in insects presented a number of interesting points, a resumé of which is given here. He observed that encapsulation of tachinids and ichneumonids may take place in larvae of the sawfly *Lyda stellata*, and suggests that in all probability it is a typical case of defense reaction. In his studies on defense reactions silk and cotton threads were threaded through larvae

and fly maggots and in a short time the threads were stained dark and, black masses, which were non-soluble in water, were deposited around them. Living larvae of vinegar flies were introduced into the bodies of different larvae and it was found that, in some cases at least, the vinegar fly larvae became enclosed, and melanized. He states that these investigations prove that the melanin formation around the parasites of *Lyda*, was a defense reaction. In discussing some of the chemistry connected with these phenomena he states that melanin substances in insects originate through the reaction of oxidized enzymes, in this case tryosinases on tyrosin. According to him, tyrosin is a separation product of proteins and that generally speaking one can expect the formation of melanin substances when protein is broken down to tyrosin by disease-causing organisms in the presence of oxidizing enzymes like tyrosinases. By the use of tyrosin paper the melanin formation in the blood of normal larvae was compared with that in the blood of larvae parasitized by tachinid flies, and no difference could be noticed either as regards the time required for the reaction or the intensity of it. Although the blood of the tachinid parasite was found to contain no tyrosinases, at least not in quantities sufficient to cause the reaction on tyrosin paper, it was ascertained that the parasite blood was capable of preventing the action of the enzymes of normal *Tipula* blood on the tyrosin paper. From these investigations he suggests that one could conclude that the tachinid could be able in some way to inactivate the enzymes which have been mobilized against it by the host, and which could lead to the formation of melanin and to subsequent enclosure. Further, on the basis of this consideration, the "funnel" described by Prell in "tachinosis," which is also formed from melanin, supports the idea of the attempt by the host to ward off the attacking parasites. The funnel-building stops at the moment when the parasite overcomes the defense of the host. It is concluded that in a normal case of parasitization the defense enzymes of the host and the contra-enzymes of the parasite are in equilibrium. The active substances are not only bound to the lymphocytes but they are also free in the blood of the insect larvae. It is suggested that the ferment complex designated as tyronsinases, will act against poisoning and form protection against foreign substances, and that they could be prevented by the use of poisons (e. g., quinine hydrochlorate). It is an open question as to whether these immunases are free in the blood stream from the beginning or whether they are mobilized by the lymphocytes at the advent of danger. He suggests that if we accept that they are present only in the lymphocytes it could be imagined that the toxic action, colloidal character, surface tension or osmotic pressure of the lymphocytes is changed in such a way by the parasites that the immunases cannot be liberated; while on the other hand the melanin which has been formed may have a detoxication effect through adsorption. The reaction of immunases in the blood of wounded larvae was compared with that of normal larvae, and it was found that the reaction took place quicker and more vigorously in wounded larvae than in normal ones. In all cases the reaction of the blood of the wounded larva was intensified. It is suggested that possibly in such cases the

bulk of available immunases would be mobilized in aid of the defense reactions. The opinion is given that there is a connection between the sudden decrease of immunases in such larvae and the sudden formation of melanin.

Compere and Smith (1932) noted that so-called "phagocytic action" was associated with the death of the eggs of *Coccophagus gurneyi* Compere within *Pseudococcus citri* (Risso), which is immune to the development of this parasite. They also observed that supernumerary eggs and larvae of this parasite were destroyed within *Ps. gahani* Green by a process very similar to the so-called "phagocytic action" observed in *Ps. citri*. In addition to killing the supernumerary eggs and larvae the development of the surviving parasite was inhibited. In some cases when a large number of eggs were deposited within a single mealybug, all the eggs and larvae, as well as the host succumbed.

Lartschenko (1932) found differences in the susceptibility of individuals of *Loxostege stricticalis* L. and *Pieris brassicae* L. to certain parasites. The eggs of *Eulimneria geniculata* Grav. deposited within *L. stricticalis* usually hatched but only a very few healthy first and second instar larvae were found and only one mature larva. Non-encysted eggs could not be found from the fifth day on after deposition. Frequently hatched larvae were found living next to the empty encysted chorions but the incubation period of such eggs was extended some days. Host caterpillars reacted to form encystments around hatched larvae as well as eggs. However, some of these encysted larvae were able to escape from the cellular masses. The molting of such larvae and the hatching of encysted eggs were observed under the binocular. He concludes from the histological studies made of parasitized *L. stricticalis* and *P. brassicae* caterpillars that the encysting mass around the eggs and larvae of the parasite is not composed of phagocytes, but of mesenchyme cells, which take over the function of connective-tissue cells. The destruction of the capsule with the perished parasite is brought about by phagocytes, which either dissolve the capsule, or destroy it by intercellular digestion.

Musebeck and Parker (1933) found that 10 to more than 30 percent of the eggs of *Hyposoter dispar* Viereck became encysted in caterpillars of *Porthetria dispar* L.

Huff (1934) found that some individuals of *Culex pipiens* L. were susceptible and others insusceptible to infection by *Plasmodium cathemerium* and *P. relictum*. Based on his studies he suggests that the same mechanism must be concerned in killing the parasites in susceptible and insusceptible individuals, the difference being one of degree. The degree of infection in a susceptible mosquito is determined by some inherent characteristic of the individual. No evidence of a cellular response of the mosquito to the introduced parasite was observed. In fact, the indifference of the phagocytes to the presence of the parasites was noted in a mosquito which had a bacterial invasion of the stomach wall, and apparently an infiltration of phagocytes in the region of the invasion. The parasites which lay within this area of infection were not attacked by the phagocytes. He concluded that phagocytosis plays no part in the resistance process.

Cameron (1934) concludes that "the fundamental response to foreign particles, cells or bacteria introduced into the body-cavity of caterpillars may be regarded primarily as a foreign body reaction, whether evoked by inert substances or highly organized living cells." He found that masses of foreign particles or cells were often encapsulated by leucocytes and lymphocytes which arranged themselves in concentric layers around such masses so as to form a rounded or oval nodule. Brownish-black pigment, similar to that developing in blood cells during true intracellular phagocytosis, appeared at the center of such nodules and in the cells in immediate contact with the particles or foreign cells. Several days later fibrils appeared at the periphery of the encapsulating cells and the nodule was eventually surrounded by what resembled a fibrous tissue wall. Such nodules persisted with little change for long periods, in some caterpillars even surviving metamorphosis. He considers this nodule formation response to be perhaps the most characteristic response to injurious substances in caterpillars. A similar response was noted also in earthworms (Cameron, 1932).

INVESTIGATION METHODS

The majority of the mealybugs used in these studies were reared as pure cultures on potato sprouts. Glass jars of different sizes, covered with muslin tops, were used as rearing chambers. Barriers of different kinds, and careful handling were necessary to prevent contamination of cultures from the "crawlers," many of which escape through the muslin tops.

Mealybugs were exposed to the parasites for oviposition in various types of containers. One that was found practical for exposing a number of mealybugs at a time, without disturbing them on the sprouts, was wide mouth quart fruit jars. A number of parasites were added to each jar and left for a few hours. Muslin tops on the jars prevented excessive condensation. After dissecting a number of mealybugs which had been attacked individually by parasites in small gelatin capsules, it was found that the parasites did not always deposit an egg when the ovipositor was inserted into a host. Therefore, it was necessary to determine by dissection, or by rearing the parasites through to adults whether an egg was deposited or not. Mealybugs attacked by parasites, but which failed to produce adult parasites within a reasonable length of time, were dissected, and if found to contain dead parasites, they were considered to be immune.[5]

After exposure to the parasites for oviposition the mealybugs were supplied with ample food and set aside for future study. The parasitized mealybugs were held in the insectary where the temperature varied from 70° F. to 85° F.

Material for histological study was killed in water (by immersing specimens in cold water and raising the temperature to 70° C.) and

[5]However, the death of some parasites might well be due to inherent weaknesses of the parasites, rather than the unsuitability of the host as a developmental medium. It would be difficult to differentiate between the two, especially in a case like *C. gurneyi*, where a number of the individuals of its normal host parasitized by it fail to produce adult parasites.

fixed in hot (70° C.) Bouin's. Whole mealybugs, as well as individual cysts,[6] were infiltrated and sectioned without special difficulty. The sections were cut 6μ in thickness and stained with Delafield's Haematoxylin and eosin. Blood smears were stained with Wright's stain.

All drawings are semi-diagramatic, although the outline, and many of the nuclei and cell walls, were put in by means of a Camera Lucida. Detailed studies were made with a compound microscope equipped with an oil emersion lens.

MEALYBUGS AS HOST MATERIAL

Mealybugs make up the subfamily Eriococcine, of the family Coccidae (Order: Homoptera). They are soft bodied insects which feed on plant juices and are sedentary during the greater part of life. Many of the species belonging to the subfamily are considered to be quite similar morphologically, if not physiologically. As might be predicted with such a group of closely related species, insects which are parasitic on one species may readily attack other species, although the latter may be immune, or at least partially so, to their development. Advantage has been taken of this in the present study. It was comparatively easy to get females of *Coccophagus gurneyi* Compere and *Leptomastix dactylopii* Howard to oviposit in the six principal species (*Pseudococcus gahani* Green, *Ps. citri* (Risso), *Ps. longispinus* (Targioni), *Ps. martimus* Ehr., *Phenacoccus gossypii* Towns. & Ckrl., *Ph. solani* Ferris) of mealybugs used in these investigations. The different species studied were sufficiently attractive to the above parasites to incite oviposition, although some of them are immune to their development.

BIOLOGIES OF PARASITES USED

Coccophagus gurneyi Compere is a small internal hymenopterous parasite which is credited with the economic control of the citrophilus mealybug (*Pseudococcus gahani* Green) in California. The parasite normally deposits its eggs free within the body fluids of mealybugs. The length of the incubation period of the fertilized eggs which produce females varies considerably, but many of the eggs hatch in three days at a temperature of 80° F. Occasionally, apparently viable fertilized eggs and small active larvae (newly hatched perhaps), are found as late as 15 to 20 days after oviposition. About 18 days are required for the larval development at the above temperature.

Unfertilized or male eggs, curiously enough, although deposited free in the body fluids like the fertilized eggs, require a modified environment before they hatch (Flanders, 1937; Cendaña, 1937). The embryonic development appears to be complete in about three days, but the planidia-form larva, which can be readily observed through the chorion, remains within the egg membranes until a suitable environmental medium for hatching is produced. These male planidia-form larvae are equipped with a type of respiratory system which makes it necessary

[6]Cysts, as used in this paper, refer to the somewhat oval masses formed as a result of the accumulation of cells around the parasites. These cysts are products of the host, for the greater part at least, rather than products of the parasites.

TABLE I

HOST SPECIFICITY IN OVIPOSITION EXHIBITED BY *Coccophagus gurneyi*

TUBE NO.	HOST SPECIES	EGGS DEPOSITED	
		Number	Percent
SERIES A. *Ps. gahani* only. Twenty mealybugs in each tube.			
A_1	*Ps. gahani*	122	
A_2	*Ps. gahani*	81	
A_3	*Ps. gahani*	111	
	Total	314	
SERIES B. Ten *Ps. gahani* and ten *Ps. citri* in each tube.			
B_1	*Ps. gahani*	94	92
	Ps. citri	8	8
B_2	*Ps. gahani*	86	80
	Ps. citri	21	20
B_3	*Ps. gahani*	76	77
	Ps. citri	23	23
	Ps. gahani	256	83
	Ps. citri	52	17
	Total	308	
	Mean difference = 68 ± 9.6 t = 7.08 P = < .05		
SERIES C. Ten *Ps. gahani* and ten *Ps. maritimus* in each tube.			
C_1	*Ps. gahani*	90	62
	Ps. maritimus	56	38
C_2	*Ps. gahani*	65	40
	Ps. maritimus	97	60
C_3	*Ps. gahani*	111	66
	Ps. maritimus	56	34
	Ps. gahani	266	56
	Ps. maritimus	209	44
	Total	475	
	Mean difference = 19 ± 26.2 t = .72 P = > .05		
SERIES D. Ten *Ps. gahani* and ten *Ps. longispinus* in each tube.			
D_1	*Ps. gahani*	82	77
	Ps. longispinus	24	23
D_2	*Ps. gahani*	59	94
	Ps. longispinus	4	6
D_3	*Ps. gahani*	96	85
	Ps. longispinus	17	15
	Ps. gahani	237	84
	Ps. longispinus	45	16
	Total	282	
	Mean difference = 64 ± 7.5 t = 8.53 P = < .05		

for them to develop in a medium containing free air, instead of in a liquid medium like that in which the female larvae develop. Therefore, the male larva does not normally escape from the egg membranes until the body fluids of the mealybug, within which it is located, are largely consumed by another parasite, either a sister *Coccophagus gurneyi* larva, or some other suitable parasite. When the male larva escapes from the egg membranes it feeds on or within the other parasite, and not on the mealybug itself.

These remarks concerning the development of the female and male larvae are of special interest in these studies since *the male eggs are usually free from attack by phagocytes within mealybugs in which female eggs and larvae are readily attacked by them.*

Leptomastix dactylopii Howard is an internal hymenopterous parasite of the common citrus mealybug (*Pseudococcus citri* (Risso)) in California. The eggs are deposited within the body cavity, but remain attached to the derm of the host by means of a stalk, a portion of which protrudes from the mealybug. The eggs hatch in about two days at a temperature near 80° F. Fifteen to twenty days are usually required for the larval development at the above temperature.

HOST SPECIFICITY IN OVIPOSITION

Some species of parasites oviposit in only one host species, while others oviposit in a number of species. The parasites used in these studies belong to the latter group.

Coccophagus gurneyi females oviposit more readily in some species of mealybugs than in others. To obtain data on the degree of attractiveness of different species of mealybugs to this parasite for oviposition a few studies were made.

Females of the parasite were collected from an emergence cage, placed in glass tubes (5″ x ½″), and supplied with food (honey). Twelve of these tubes, each containing ten females, were used for oviposition chambers. The next day after collecting and feeding the parasites, twenty mealybugs, divided as shown in Table I, were added to each tube and exposed to the parasites for 150 minutes. Individuals of *Pseudococcus gahani* were added to each tube since this species is considered to be the normal host of the parasite. The three lots of *Ps. gahani* confined with *Ps. citri* received on an average 68 eggs more than *Ps. citri*. The standard error being 9.6 eggs, the difference is significant. The lots of *Ps. gahani* exposed with *Ps. longispinus* received on an average 64 eggs more than *Ps. longispinus*. Again the difference is significant since the standard error is 7.5 eggs. The standard error of the difference between the number of eggs deposited in *Ps. gahani* and *Ps. martimus* is not significant, the former being even greater than the mean difference.

These data indicate that the attractiveness of a host to a parasite for oviposition is not necessarily an index to its susceptibility to the parasite, although in many cases it probably is. It would follow that a female parasite oviposits more readily in one particular host species than another, not because one of the hosts is better suited for the development of the parasite, but because it is more attractive to the parasite for oviposition.

TABLE II

HOST SPECIFICITY IN OVIPOSITION EXHIBITED BY *Leptomastix dactylopii*

TUBE NO.	HOST SPECIES	EGGS DEPOSITED	
		Number	Percent
SERIES 1. *Ps. citri* only. Twenty mealybugs in each tube.			
1a	*Ps. citri*	66	
1b	*Ps. citri*	65	
1c	*Ps. citri*	76	
	Total	207	
SERIES 2. Ten *Ps. citri* and ten *Ps. maritimus* in each tube.			
2a	*Ps. citri*	38	53
	Ps. martimus	34	47
2b	*Ps. citri*	62	77
	Ps. maritimus	19	23
2c	*Ps. citri*	42	67
	Ps. maritimus	21	33
	Ps. citri	142	66
	Ps. maritimus	74	34
	Total	216	
Mean difference = 22.7 ± 11.3 t = 2.00 P = >.05			
SERIES 3. Ten *Ps. citri* and ten *Ps. longispinus* in each tube.			
3a	*Ps. citri*	21	55
	Ps. longispinus	17	45
3b	*Ps. citri*	36	55
	Ps. longispinus	30	45
3c	*Ps. citri*	21	60
	Ps. longispinus	14	40
	Ps. citri	78	56
	Ps. longispinus	61	44
	Total	139	
Mean difference = 5.7 ± .9 t = 6.33 P = <.05			
SERIES 4. Ten *Ps. citri* and ten *Ps. gahani* in each tube.			
4a	*Ps. citri*	43	75
	Ps. gahani	14	25
4b	*Ps. citri*	41	75
	Ps. gahani	14	25
4c	*Ps. citri*	40	83
	Ps. gahani	8	17
	Ps. citri	124	78
	Ps. gahani	36	22
	Total	160	
Mean difference = 29.3 ± 1.5 t = 19.5 P = <.01			

Leptomastix dactylopii.—Females of *L. dactylopii* were used in an experiment, similar to the one above, designed to secure data on the attractiveness of different species of mealybugs to the parasite for oviposition. The parasites were collected from an emergence cage, ten females placed into each of twelve glass tubes (6″ x ¾″), fed and left overnight before adding the mealybugs. To each tube, twenty mealybugs, divided as shown in the following table, were added and exposed to the parasites for 240 minutes. *Ps. citri* is the normal host of this parasite, therefore, individuals of this species were included in each tube. The data in Table II were obtained from dissecting the mealybugs.

The three lots of *Ps. citri* confined with *Ps. gahani* received on an average 29.3 eggs more than *Ps. gahani*. The standard error being 1.5 eggs, the difference is highly significant. *Ps. citri* exposed with *Ps. longispinus* received on an average 5.7 eggs more than *Ps. longispinus*, and since the standard error of the difference is only .9 eggs, the difference is significant. However, the difference between the number of eggs deposited in *Ps. citri* and *Ps. maritimus* is not significant. In this case the mean difference was 22.7 eggs, but the standard error was 11.3 eggs.

No difficulty was encountered in rearing adults of the parasite from *Ps. citri*, and many were reared from *Ps. longispinus*, although when reared from the latter host, the adults were usually small. No adults were reared from *Ps. gahani* or *Ps. maritimus*.

Discussion.—Host specificity in oviposition of parasites is a phenomenon which has been observed many times, but comparatively few quantitative data are available on it. There are no doubt many host species which are free from parasitization by specific parasites not because they are immune to the development of the larvae of the parasites, but because they are not sufficiently attractive to the parasites in question to incite oviposition. The data presented above indicate that the reverse condition is true[7]; that is, a mealybug species may be attractive enough to incite oviposition, but may be immune to the development of the larvae within it.

Physical characteristics, as well as chemical and physiological reactions, enter into host specificity in oviposition. It was noted that females of *C. gurneyi* and *L. dactylopii* appeared to have more difficulty in inserting their ovipositors in some species of mealybugs than in others. This was especially noticeable with females of both parasites attacking *Puto ambigua*. Several individuals of this mealybug were dissected after being attacked by females of the former parasite, but no eggs had been deposited. However, although only a few eggs were deposited by *C. gurneyi* females within *Puto ambigua*, an adult female of the parasite was reared from this host. Freedom, or partial freedom from oviposition like this may be a result of an exceptionally thick integument, a large amount of waxy covering, the activity of the host species, or other factors. Host specificity in oviposition depends first upon the attractiveness of the host species, but other factors may be important.

[7]However, contact of the preferred hosts (*Ps. gahani* and *Ps. citri*) with the other host species in the tubes may have affected the attractiveness of the latter to the parasites.

RESISTANCE AND CELLULAR RESPONSE (PHAGOCYTOSIS) OF HOSTS TO PARASITES

The different species of mealybugs tested showed marked differences in their resistance to the development of *Coccophagus gurneyi* and *Leptomastix dactylopii* within them. About ten thousand mealybugs were dissected at different intervals after parasitization in an attempt to determine the degree of resistance of the different host species, when the destroyed parasites die, and as much as possible about the relation of phagocytosis, if any, to the resistance of the host. The data obtained as a result of the procedure followed were not all that could be desired. Different species of mealybugs develop at different rates, and no doubt in certain cases, an individual of a rapidly developing species, completes its development, lays its eggs and dies of senesence, before the parasite, which it harbors, has sufficient time to complete its development. Invariably, a number of mealybugs were found dead at the time of dissection, and since some were dry and hardened, it was not determined whether they contained parasites or not. Even when a dead mealybug was dissected and found to contain dead parasite eggs or larvae, it could not be ascertained whether the parasite was dead at the time the mealybug died or not. Because of these complications, only mealybugs which were living at the time of dissection were included in the data presented in the following tables. Infertile eggs of *Coccophagus gurneyi*, which could be readily determined by the heavily sclerotized planidia-form larvae within, were not included in the data presented.[8]

Several hundred parasitized mealybugs of each of the six species studied were held for adult parasite emergence. An attempt was made to determine the percentage of emergence of the parasites from each host species, but the data obtained were not satisfactory. The principal difficulty was that females did not always deposit an egg when the ovipositor was inserted. However, by holding several hundred parasitized mealybugs, sampled for percentage of parasitization by dissection, some indication of the immunity of these different species of mealybugs to *C. gurneyi* and *L. dactylopii* was determined.

Insects attacked by parasitic insect species may or may not exhibit apparent cellular responses resulting in the formation of agglomerations of cells around the introduced parasite eggs or larvae. The formation of agglomerations of this nature have been associated with immunity, and referred to as phagocytosis. The phenomenon can hardly be termed a true intracellular one like that exhibited where bacteria are definitely ingested and digested by phagocytes, but the reactions concerned are probably primarily the same. Throughout these investigations quantitative and qualitative studies have been made of this phenomenon within the mealybugs in response to the presence of eggs and larvae of *C. gurneyi* and *L. dactylopii*. Agglomerations formed around both

[8]As explained before, the development of the male larvae, as well as their morphological structure, is entirely different from that of female larvae. The unhatched male larvae may remain alive for weeks within mealybugs immune to the development of female larvae. The development of the infertile eggs was apparently the same in hosts immune to the development of the fertile eggs as in susceptible hosts.

parasites within *Ps. gahani* and *Ps. maritimus* were sectioned and found to vary in structure in the different host species. However, the agglomerations formed around either parasite within the same host species were similar in appearance, and in histological structure.

The discussion of the different host species and parasites on the following pages are based primarily on data obtained from dissections. These dissections were made throughout the developmental period of the parasite larvae. Hundreds of mealybugs were dissected from one to forty days after parasitization, in addition to the ones used in the tables. The table below shows the number of parasites included and parasitized mealybugs dissected for the quantitative studies presented on immunity.

COCCOPHAGUS GURNEYI ON PSEUDOCOCCUS GAHANI

Resistance.—Pseudococcus gahani is considered to be the normal host of *C. gurneyi*, but apparently even a number of the individuals of this

TABLE III

SUMMARY TABLE SHOWING THE NUMBER OF PARASITIZED MEALYBUGS DISSECTED AND THE NUMBER OF PARASITES OBTAINED FROM THEM

HOST SPECIES	*Coccophagus gurneyi*		*Leptomastix dactylopii*	
	No. Parasites	No. Mealybugs	No. Parasites	No. Mealybugs
Ps. gahani	1,942	775	422	281
Ps. citri	1,348	506	1,632	590
Ps. longispinus	1,106	507	906	591
Ps. maritimus	2,236	576	383	222
Ph. gossypii	1,403	994	339	286
Ph. solani	1,411	705	427	269
Totals	9,446	4,063	4,109	2,239

Total number of parasites—13,555.
Total number of mealybugs—6,302.

species are immune to the development of the parasite within them. It was especially difficult to get quantitative data which would show when the parasite larvae died within this host. There were apparent differences in the susceptibility of different lots.[9] In addition, where the dissections were made several days after parasitization the small larvae within immune mealybugs may have disintegrated to such an extent that they were not discovered.

Definite quantitative data on the effect of parasitization on individuals in which the parasite was unable to develop were not obtained, but it was noted that a number of such individuals, as well as mealybugs which contained small active larvae of the parasite, deposited a large percent of their eggs (Table III).

[9]See discussion on this point in regard to the development of *C. gurneyi* within *Ps. maritimus* (page 212).

It appears that the parasites which are able to develop for a few days within mealybugs of this species are usually able to complete their development. However, a small percent of the larvae which are able to grow and molt die before completing their development. It is not unusual to find dead mealybugs which contain well-developed, but dead

TABLE IV

RESISTANCE OF DIFFERENT SPECIES OF MEALYBUGS TO *C. gurneyi*

NUMBER OF PARASITIZED MEALYBUGS DISSECTED	NUMBER OF DAYS AFTER PARASITIZATION	NUMBER OF MEALYBUGS CONTAINING		PERCENT OF MEALYBUGS CONTAINING LIVING PARASITES
		Living Parasites	Dead Parasites Only	
Pseudococcus gahani				
101	9	77	24	76
243	17	206	37	85
269	25	253*	16	94
Pseudococcus citri				
156		77	79	49
79	12	14	65	18
85	16	42	43	49
101	23	0	101	0
Pseudococcus longispinus				
171	9	162	9	95
116	15	90*	26	78
124	26	114	10	92
Pseudococcus maritimus				
174	9	51	123	29
135	19	31	104	23
194	29	34*	160	18
Phenacoccus gossypii				
131	9	96	35	73
240	13	135	105	56
570	20	230	340	40
Phenacoccus solani				
335	9	290	45	87
158	18	130	28	82
166	26	102*	64	61

*Some of these were adults which emerged before the dissections were made.

parasite larvae. Compere and Smith (1932) observed that large numbers of mealybugs of this species died when exposed to heavy superparasitization by this parasite. No quantitative data were obtained on this point in these investigations.

Hundreds of adult females were reared from this species of mealybugs.

Phagocytosis.—A number of eggs of *C. gurneyi* deposited within *P. gahani* are eventually phagocytized, although *P. gahani* is considered to be the normal host of the parasite. The phagocytized eggs and larvae are conspicuous in this host for several days after parasitization, due to the reddish color of the definite cysts formed around them. In mealybugs, within which several parasite eggs were deposited, two or more eggs were often enclosed within the same cyst. Apparently, encystment does not occur until about the time the eggs are ready to hatch, which was usually about three to four days after deposition. It appears that only a few hours are required for encystment to take place

TABLE V

PHAGOCYTOSIS OF DEAD SOLITARY AND SUPERNUMERARY EGGS AND LARVAE OF *C. gurneyi* AT DIFFERENT INTERVALS AFTER PARASITIZATION

HOST SPECIES	NO. DAYS AFTER PARASITIZATION	SOLITARY EGGS AND LARVAE			SUPERNUMERARY EGGS AND LARVAE		
		No. Phag.	No. not Phag.	Percent Phag.	No. Phag.	No. not Phag.	Percent Phag.
Ps. gahani	9	15	0	100	195	33	85.5
	17	22	7	75.8	39	1	97.5
	25	1	10	9.0	5	6	45.4
Ps. citri	9	15	0	100	452	6	98.6
	12	31	1	96.8	131	0	100
	16	21	5	80.7	135	0	100
	23	54	0	100	185	0	100
Ps. longispinus	9	0	4	0.0	7	230	2.9
	15	1	2	33.3	109	148	42.4
	26	0	6	0.0	9	18	33.3
Ps. maritimus	9	30	0	100	513	0	100
	19	11	0	100	294	1	99.6
	29	75	0	100	457	4	99.1
Ph. gossypii	9	16	12	57.1	42	17	71.1
	13	61	1	98.3	165	1	99.3
	20	159	111	58.8	153	44	77.6
Ph. solani	9	0	9	0.0	4	659	0.6
	18	3	24	11.1	0	3	0.0
	26	16	32	33.3	7	40	14.8

after the cells begin to accumulate around the parasites. No partially encysted eggs or larvae were found. The cysts are more or less spherical in shape. Phagocytized eggs and larvae hold their form, and remain pliable for a number of days but eventually they become melanized,[10] lose their characteristic form, and the cysts themselves become hardened and melanized.

Seventy-seven out of 101 parasitized mealybugs dissected nine days after parasitization contained living parasites and 24 contained only dead parasites. Twenty-one of the 24 mealybugs containing only dead

[10]Melanization, as used here, refers to the darkening and hardening of the cells or material, or both, immediately surrounding the parasite eggs or larvae, as well as the eggs and larvae themselves. The parasites are not noticeably affected at first, but only the substance or cells which directly surround them.

parasites, contained one or more phagocytized eggs or larvae. However, 55 percent of the mealybugs with living parasites contained in addition phagocytized eggs or larvae, making a total of 64 percent, or 66 mealybugs, which contained phagocytized parasites. A large percent of the dead solitary and supernumerary larvae are phagocytized within this host (Table V). A number of apparently healthy active larvae were noted which were completely encysted (Table IX).

LEPTOMASTIX DACTYLOPII ON PSEUDOCOCCUS GAHANI

Resistance.—*Ps. gahani* may well be considered as immune to *L. dactylopii*. Only about 15 percent of the mealybugs dissected seven days after parasitization contained living larvae, and over half of them were surrounded by phagocytes.[11] Over ninety percent of the eggs are encysted within 60 hours after deposition when held at a temperature near 80° F. A discussion on phagocytosis[12] or encapsulation in regard to this species is given later.

Adults of the parasite were not reared from this mealybug although several hundred were parasitized and held for that purpose.

Phagocytosis.—Most of the eggs of *L. dactylopii* deposited within *Ps. gahani* became phagocytized about the time they normally hatch, which was two to three days after deposition. The phagocytized eggs and larvae are quite conspicuous, being reddish in color for a number of days after encystment, like phagocytized eggs and larvae of *C. gurneyi* within this host. The reddish cysts can be readily observed through the derm of the host. Encystment apparently begins at the posterior end of the larvae where they are attached to the body wall of the host. Active larvae have been observed which were completely surrounded with the exception of the anterior end, which was free. It appears that the cysts develop rapidly after development is once initiated, although intermediate stages were observed in a few cases.

The histology of the cysts formed around *C. gurneyi* and *L. dactylopii* eggs and larvae within *Ps. gahani* is essentially the same. The cells of the cyst immediately adjacent to the parasite were somewhat flatter than those near the periphery. Probably these flattened cells, and the ones near the periphery, are of the same type, the change in shape being due to the increased crowding of the cells around the parasite. During the early stages in the development of the cysts (48 to 90 hours after deposition) around *L. dactylopii* within *Ps. gahani* there is no melanization connected with the cyst proper (Figs. 1 and 2). As the cysts increase in age, streaks of a slightly dark tinge can be noted. However, there is no definite melanized layer similar to that formed

[11]Phagocytes, as used in this paper, refer to the cells attracted to the parasite eggs or larvae. They were somewhat oval in shape and never definitely elongate or spindle-shaped.

[12]Phagocytosis, as used in this paper, is not confined to intracellular digestion proper, but has reference to the formation of agglomerations of cells around parasites and other foreign bodies. Parasites surrounded by a thin melanized sheath were considered to be phagocitized, although cells were not always identified in the sheaths. Such sheaths may possibly be composed largely of melanin formed in the absence of cells, but it appears more likely that they are composed of melanized cells attracted to the parasite, as well as of chemical substances present.

around the parasites within *Ps. maritimus* (compare Figures 2 and 4). Perhaps that is the reason that encapsulated active larvae live longer in *Ps. gahani* than in *Ps. maritimus*. The sections of encysted eggs within *Ps. maritimus* showed the melanized layer to be quite dense and therefore probably much more impervious to nutritives and certain gases essential to the life of the parasite than the cyst of living cells.

TABLE VI

RESISTANCE OF DIFFERENT SPECIES OF MEALYBUGS TO *L. dactylopii*

NUMBER OF PARASITIZED MEALYBUGS DISSECTED	NUMBER OF DAYS AFTER PARASITIZATION	NUMBER OF MEALYBUGS CONTAINING		PERCENT OF MEALYBUGS CONTAINING LIVING PARASITES
		Living Parasites	Dead Parasites Only	
Pseudococcus citri				
116	7	112	4	97
173	12	171	2	99
127	17	126*	1	99
Pseudococcus gahani				
121	7	17	104	14
84	14	0	84	0
Pseudococcus longispinus				
208	7	171	37	82
78	14	42	36	54
104	23	23*	81	22
143	28	49*	94	34
108	44	37*	71	34
Pseudococcus maritimus				
158	7	2	156	1
Phenacoccus gossypii				
123	7	44	79	36
121	14	14	107	12
Phenococcus solani				
101	7	85	16	84
80	14	59	21	74
108	19	96*	12	89

*A large number of these were adults which emerged before the dissections were made.

The origin of the cells which comprise the encysting mass was not determined. The outer cells of the cysts contain a number of vacuoles. Because of the presence of vacuoles Lartschenko considered the cells of certain cysts to be mesenchyme cells, which could transform into typical fat cells, but which in the presence of a foreign body could take over the function of connective tissue cells. He states that the place of origin is in the accumulations of young cells in the pericardial region.

Like the encysted eggs and larvae of *C. gurneyi* within this host, the phagocytized eggs and larvae of *L. dactylopii* remain pliable and undark-

ened for a number of days after they become phagocytized. Eventually the parasites, and the surrounding mass, become melanized and lose their original form. These melanized cysts are surrounded by a layer of fibrous material.

One hundred and twenty-one parasitized mealybugs were dissected seven days after parasitization and 113, or about 93 percent, of these contained phagocytized parasites. A total of 16 mealybugs contained living parasite larvae, but eight of these living parasites were phagocytized. Additional dissection records indicate that all eggs and larvae are dead and phagocytized 14 days after parasitization. No adults of the parasite were reared from this mealybug.

TABLE VII

PHAGOCYTOSIS OF DEAD SOLITARY AND SUPERNUMERARY EGGS AND LARVAE OF *Leptomastix dactylopii* IN MEALYBUGS AT DIFFERENT INTERVALS AFTER PARASITIZATION

HOST SPECIES	NO. DAYS AFTER PARASITIZATION	SOLITARY EGGS AND LARVAE			SUPERNUMERARY EGGS AND LARVAE		
		No. Phag.	No. not Phag.	Percent Phag.	No. Phag.	No. not Phag.	Percent Phag.
Ps. citri	7	0	4	0.0	2	29	6.4
	12	0	1	0.0	11	85	11.4
Ps. gahani	7	76	0	100	63	0	100
	14	54	0	100	88	0	100
Ps. longispinus	7	13	0	100	60	75	44.4
	13	37	3	92.5	21	0	100
	23	45	0	100	56	0	100
	28	29	32	47.5	43	33	56.5
Ps. maritimus	7	99	0	100	141	0	100
Ph. gossypii	7	60	3	95.2	35	7	83.3
	14	86	3	96.2	32	12	72.7
	21	16	0	100	15	0	100
Ph. solani	7	14	0	100	17	1	94.4
	14	12	1	92.3	6	0	100
	19	2	6	25.0	3	6	33.3

COCCOPHAGUS GURNEYI ON PSEUDOCOCCUS CITRI

Resistance.—Pseudococcus citri is practically immune to *Coccophagus gurneyi*. However, dissections made at different intervals after parasitization indicate that many of the parasite larvae remain alive for several days after hatching, although they eventually succumb before completing their development. It can be seen from Table IV that a large number of larvae may be alive at the end of nine days, and some live for sixteen days or more. However, no mealybugs were dissected which contained living parasite larvae more than eighteen days after parasitization.

The percent of individuals susceptible to the parasite varied considerably in different lots of mealybugs. This particular point is discussed more at length in connection with *Ps. maritimus*, where even greater

variations occurred. Such variations in susceptibility within a species indicate that large numbers should be used in immunity studies.

The developmental rate of a parasite within its host, and the development of the host itself, may be important from the standpoint of susceptibility and immunity. In the case of *C. gurneyi* developing within *Ps. citri* apparently the developmental rate of the parasite larvae is retarded considerably. The parasite larvae, ten to fifteen days after the deposition of the eggs are much smaller than larvae of the same age in a favorable host like *Ps. gahani*.

Only two female adults were reared from several hundred parasitized mealybugs held for adult emergence.[13]

Phagocytosis.—The female eggs and larvae of *C. gurneyi* are eventually phagocytized in perhaps over 99 percent of the *Ps. citri* mealybugs attacked by this parasite. The cysts are quite different in appearance from those formed around the parasite within *Ps. gahani*. Newly formed cysts are composed of whitish cells and within a short time after they are formed the parasites within become hardened and melanized, and lose their original form. The cysts themselves likewise become melanized near the parasites and within a comparatively short time the whole cyst becomes black and hard. These black pellets can be observed through the derm of the host.

One hundred and fifty-six parasitized mealybugs were dissected nine days after parasitization and the following data obtained: Living parasites were found within 77 of these mealybugs and all the dead parasites within the other 79, or about 50 percent, were phagocytized. A total of 121, or about 77 percent of the 156 mealybugs contained phagocytized parasites. Other disssections indicate that practically all of the parasites are eventually phagocytized within this host.

LEPTOMASTIX DACTYLOPII ON PSEUDOCOCCUS CITRI

Resistance.—*Ps. citri* is considered to be the normal host of *L. dactylopii*. Data given in Table V indicate that it is highly susceptible to the parasite.

Adults were reared in large numbers from this host.

Phagocytosis.—*L. dactylopii* eggs deposited within *Ps. citri* are seldom phagocytized. The ones observed to be phagocytized occurred within hosts containing more than one parasite egg or larva. The cysts observed were similar in appearance to those formed around *C. gurneyi* in this host.

Of 116 parasitized mealybugs dissected seven days after parasitization 112 contained living larvae and the other four contained dead unphagocytized larvae. Two of the 112 susceptible mealybugs contained dead phagocytized larvae in addition to living larvae. Based on a large number of dissections made throughout the developmental period of the parasite a very small per cent of the eggs deposited in *Ps. citri* are ever phagocytized.

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[13]The mummies from which these females emerged were mounted and determined as *Ps. citri* by taxonomic specialists in this group of insects.

COCCOPHAGUS GURNEYI ON PSEUDOCOCCUS LONGISPINUS

Resistance.—A large percent of the individuals of *Ps. longispinus* are susceptible to *C. gurneyi.* The figures given in Table IV bear this out and a large number of adults were reared from the host.

Phagocytosis.—Many of the eggs of *C. gurneyi* deposited within *Ps. longispinus* die before larval development is complete, and a limited number of these are phagocytized. The cysts formed appear to be quite similar to those formed around the parasites within *Ps. citri.*

One hundred and seventy-one parasitized mealybugs were dissected nine days after parasitization and 162 contained living parasites. Six contained only dead unphagocytized larvae and the other three contained dead phagocytized larvae. A total of six mealybugs, or about four percent, contained phagocytized larvae, three of these harboring living parasites also. Additional dissections indicate that many of the larvae which are living nine days after parasitization finally die. Four to six weeks after parasitization, a few of the dead larvae are surrounded by what appear to be melanized hardened cysts; others are melanized, with little or no indication of a cyst; but the majority of them appear to be gradually disintegrating within the body fluids of the host without attracting cells to them, or becoming melanized or hardened.

LEPTOMASTIX DACTYLOPII ON PSEUDOCOCCUS LONGISPINUS

Resistance.—A small percent of the individuals of *L. dactylopii* are able to develop successfully in *Ps. longispinus* mealybugs. Most of the eggs hatch, but the majority of the larvae die before completing their development. The larvae may die at any stage from egg to last larval instar. It is evident from Table V that a large percent of the parasitized mealybugs contain living parasite larvae seven days after parasitization, while over half of these parasites finally succumb before larval development is complete.

Several dozen adult parasites were reared from this host, but many of them were noticeably small.

Phagocytosis.—In *Ps. longispinus* a higher percent of the eggs of *L. dactylopii* become phagocytized than of *C. gurneyi.* The cysts formed are similar to those formed around either parasites within *Ps. citri.*

Dissections were made of 208 parasitized mealybugs seven days after parasitization and 171 of the 208 contained living larvae. A total of 58 mealybugs, or about 28 percent, contained phagocytized larvae, 29 of which contained living larvae in addition to those phagocytized.

Dissections made three to four weeks after parasitization show that the dead larvae may at that time be either surrounded by melanized cysts; melanized with little or no accumulation of cells around them; or they may be gradually disintegrating within the host fluids without melanization or phagocytosis.

COCCOPHAGUS GURNEYI ON PSEUDOCOCCUS MARITIMUS

Resistance.—Ps. maritimus exhibits a high degree of immunity to *C. gurneyi.* From the data secured, (Table IV), about 70 to 80 percent

of the individuals are immune, and in several lots, composed of 300 or more individuals, apparently all individuals were immune. The majority of the parasite eggs fail to hatch in this host, but it appears that a large percent of the larvae which hatch complete their development.

Several dozen adults of this parasite were reared, although only a small percent of the individuals are susceptible.

Phagocytosis.—A large percent of the eggs of *C. gurneyi* deposited within *Ps. maritimus* are phagocytized. The cysts formed around these eggs are noticeably different from those produced in the other species studied. They appear to be smaller than those developing in *Ps. gahani.* These somewhat reddish brown cysts are readily observed within dissected mealybugs and the eggs within them retain their form for weeks after encystment. Phagocytosis is initiated about the time the eggs normally hatch, which was three to four days after deposition. Once cells begin to accumulate around the eggs, apparently only a short time is required for complete encystment to take place, for partially encysted eggs were not observed, although several hundred eggs were examined from one to six days after deposition. The histology of the cysts is discussed more in detail in connection with cysts formed around *L. dactylopii* eggs in this host.

One hundred and seventy-four mealybugs were dissected nine days after parasitization and 51 contained living parasites, while the other 123 contained only dead phagocytized eggs or larvae. Thirty-four of the 51 mealybugs which contained living parasites, harbored dead phagocytized parasites also. Therefore, a total of 157, or about 90 percent of the mealybugs contained dead phagocytized parasites.

A few of the dead larvae found within mealybugs two to four weeks after parasitization were disintegrating without any apparent accumulation of cells around them. However, it appears that all dead eggs are eventually melanized and phagocytized, and that the majority of the dead larvae are also.

LEPTOMASTIX DACTYLOPII ON PSEUDOCOCCUS MARITIMUS

Resistance.—*Ps. maritimus* is apparently immune to *L. dactylopii.* However, many of the eggs hatch, and the larvae may live varying lengths of time up to seven days or more after parasitization. None has been found to live more than seven days, and only two mealybugs out of 158 dissected seven days after parasitization contained living parasite larvae.

No adults of the parasite were reared from several hundred parasitized mealybugs held for emergence records.

Phagocytosis.—Some of the *L. dactylopii* eggs deposited within *Ps. maritimus* hatch, but eventually all eggs and larvae become melanized and phagocytized. The cysts formed closely resemble those formed around *C. gurneyi* within this host and their histological structure is essentially the same. In either case, the phagocytic cells do not accumulate around the eggs until about the time they normally hatch. Early in the development of the cyst a distinct dense melanized layer can be observed (after sectioning) immediately surrounding the egg (Fig. 3). This melanized layer was not exactly homogenous in structure,

but there was no indication of a definite cellular structure. A number of phagocytic cells form a thin cyst around the melanized capsule. After a few days the whole cyst becomes melanized and hard, but by this time an outer layer of semi-transparant fibrous-like matter has been formed around the cyst. Eggs may remain encysted in this manner for at least six weeks within living mealy-bugs with comparatively little further change.

Probably the dense melanized capsule formed immediately around the eggs is much more impervious to the essential passage of nutrients and gases than the outer cellular layer of the cyst. Therefore, a layer of this type could possibly have much more detrimental effect upon the egg than a cyst of only living cells. No eggs surrounded by a melanized layer of this type were observed to hatch.

A total of 158 parastized mealybugs were dissected seven days after parasitization and only two of them contained living parasite larvae. The dead parasites within the other 156 mealybugs were all melanized and phagocytized. Additional dissections indicate that all individuals die either as eggs or larvae within this species and become melanized and phagocytized.

COCCOPHAGUS GURNEYI ON PHENACOCCUS GOSSYPII

Resistance.—Ph. gossypii is another host species which exhibits definite resistance to *C. gurneyi*. The majority of the eggs hatch, and a large number of the larvae develop for several days, but most of them finally die before completing their development. From the dissections made and recorded in Table IV, 73 percent of the parasitized mealybugs contained active parasite larvae nine days after parasitization, 56 percent four days later, and 40 percent seven days later, or twenty days after parasitization. Several dead large larvae were found within mealybugs dissected several days after parasitization. Although some of the larvae complete their development and emerge as adults, this group is represented by only a small percent of the eggs deposited.

Dozens of adults of the parasite were reared from this host species; however, several lots of 300 or more parasitized mealybugs were held for emergence records which produced no adults.

Phagocytosis.—A number of the eggs and larvae of *C. gurneyi* within *Ph. gossypii* became melanized. The dead melanized eggs and larvae are eventually surrounded by a whitish fibrous material, in which no cells were identified. Melanized sheaths have been removed from living, as well as dead, parasite larvae, and the larvae were still whitish. However, eventually the dead parasites themselves become darkened, hard and brittle. Fibrous material, apparently similar to this, but not so much of it, has been repeatedly observed around black hard particles within other mealybugs. Apparently the fibrous material is a secondary formation around inert foreign bodies.

One hundred and thirty-one parasitized mealybugs were dissected nine days after parasitization and 96 of them contained living parasites. Seven of these, and ten of the remaining 35, contained melanized parasites. Dissections made two to four weeks after parasitization show that although some dead parasite larvae become melanized, a large

number of them disintegrate within the body fluids of the mealybug without melanization or any apparent cellular formation around them.

LEPTOMASTIX DACTYLOPII ON PHENACOCCUS GOSSYPII

Resistance.—A very small percent of the individuals of *Ph. gossypii* tested were susceptible to *L. dactylopii.* Again, the majority of the eggs hatch, but a large percent of the larvae die within a short time. Thirty-six percent of the mealybugs dissected seven days after parasitization contained living parasite larvae, while only 12 percent contained living larvae seven days later or 14 days after parasitization.

A total of about a dozen adults were reared from several lots of 300 or more parasitized mealybugs. Conservatively, less than one percent of the parasitized individuals produced adult parasites.

Phagocytosis.—The majority of the eggs of *L. dactylopii* deposited within *Ph. gossypii* die before larval development is complete. A large percent of these dead eggs and larvae is eventually melanized. The melanized sheaths which surround the larvae (Fig. 5) have a close resemblance to the so-called "respiratory funnels" in which certain tachinids develop.

The sheath develops around the posterior end of the larva first, and as it continues to increase in size, more and more of the larva is covered by it. Active larvae, with only the first three or four anterior segments free, have been observed (Fig. 5). The integument of such larvae is apparently unaffected by the process at that time. However, eventually, after complete encapsulation and death of the larvae, the larvae themselves become melanized and brittle. Such melanized larvae are surrounded by a layer of fibrous-like material similar to that noted in other host species, but the layer is thicker in this host (*Ph. gossypii*).

One hundred and twenty-three parasitized mealybugs were dissected seven days after parasitization and the following data secured: 44 contained living larvae, and 76 of the remaining 79 which contained only dead parasites, contained melanized parasites. Numerous dissections were made and it appears probable that there are very few dead larvae which are not eventually melanized. Nevertheless, some appear to disintegrate without any apparent melanization.

COCCOPHAGUS GURNEYI ON PHENACOCCUS SOLANI

Resistance.—Apparently, only about one-half of the individuals of *Ph. solani* are sufficiently favorable to *C. gurneyi* larvae to allow them to develop successfully within them, although most of the eggs hatch. Table IV gives some information on the mortality rate during the developmental period of the larvae. Eighty-seven percent of the mealybugs contained living parasites nine days after parasitization, 82 percent nine days later, and 61 percent eight days later, or twenty-six days after parasitization.

Several hundred adult parasites were reared from this host.

Phagocytosis.—Only occasionally are the eggs and larvae of *C. gurneyi* phagocytized within *Ph. solani.* The ones that are phagocytized

appear similar to those phagocytized within *Ps. longispinus* described above.

Out of a total of 335 parasitized mealybugs dissected nine days after parasitization only three contained phagocytized parasites and all of those contained living larvae also. From numerous dissection data it appears that the majority of the living and dead *C. gurneyi* eggs and larvae are free from phagocytosis within *Ph. solani.*

LEPTOMASTIX DACTYLOPII ON PHENACOCCUS SOLANI

Resistance.—A large percent of the individuals of *Ph. solani* are susceptible to the development of *L. dactylopii* within them (Table V). Hundreds of adults of the parasite were reared from this host species.

Phagocytosis.—A small percent of the larvae of *L. dactylopii* are eventually melanized or slightly phagocytized within *Ph. solani.* Apparently, very few cells are attracted to such larvae for definite cysts are seldom formed.

One hundred and one parasitized mealybugs were dissected seven days after parasitization and the following information obtained; 85 contained living parasites and the other 16 contained only melanized or slightly phagocytized larvae. Nine of the mealybugs containing living parasites also harbored lightly phagocytized larvae. Supplementary dissection data show that dead larvae in an advanced stage of disintegration, without any apparent melanization or phagocytosis, as well as lightly phagocytized and melanized larvae, may be found as late as four weeks after parasitization.

DISCUSSION

Resistance.—These investigations show that the different species of mealybugs studied vary greatly in their susceptibility to the development of the parasites. They vary from a condition where no adult parasites were reared to so-called complete susceptibility, where the mortality of the parasite is quite low. The six host species used in these studies exhibited many intermediate conditions between the two mentioned above.

In addition to exhibiting varying degrees of susceptibility from the viewpoint of adult parasite emergence, they showed differences as to the length of life of the parasite larvae which died within them before completing development and in the cellular reactions of the hosts to the parasites. The parasite eggs and larvae usually die in one of the species within a comparatively short time after parasitization, while in other species the eggs may all hatch and the larvae remain alive for several days. In one case at least, fewer parasites completed their development in the host species in which the parasites eggs usually hatch and develop for several days, than in the host species where a large number die within a short time after parasitization. *Ps. citri* and *Ps. maritimus,* when parasitized by *C. gurneyi,* react in the manner described in the foregoing sentence.

Phagocytosis. The difference in the intensity of the apparent cellular reactions exhibited by the different species of mealybugs to parasitiza-

tion by the two parasites is pronounced, as well as differences in the percent of individuals of the different species exhibiting any apparent cellular reactions. In *Ps. gahani*, the encysted eggs and larvae are surrounded by several layers of cells which form a definite cyst, while comparatively few cells are attracted to the parasites in *Ps. maritimus*. The sheaths or capsules formed around either parasite within *Ph. gossypii* are markedly different from the definite cysts formed within *Ps. gahani*. As to the differences in the percent of individuals of the different species which exhibit noticeable cellular reactions to the parasites, *Ps. maritimus* and *Ph. solani* are good examples showing extremes. A large percent of the eggs and larvae of *C. gurneyi* become surrounded wit cells in *Ps. maritimus*, while a comparatively low percent become encysted in *Ph. solani*. Death of the parasites in the latter host might be attributed to starvation, but we have no conclusive evidence.

Minute cactus thorns were inserted into mealybugs representing the six species above and the resulting phagocytosis and melanization were similar, superficially at least, to that initiated by parasites in the respective species. There was a pronounced accumulation of cells around the thorns inserted into *Ps. gahani* and conspicuous melanization around those inserted into *Ph. gossypii*. It seems logical to conclude from these observations that the host species influence to a large extent the kind of reaction resulting from the introduction of a specific foreign body, as well as, the intensity of the reaction.

DEVELOPMENTAL RATE OF PARASITES WITHIN DIFFERENT HOSTS

Coccophagus gurneyi larvae require more time to complete their development in some hosts than in others. This was first noted from dissections and an attempt was made to obtain comparable data on the time required for development from egg to adult within the different hosts. However, only a limited number of adults were obtained in these studies due to the difficulty encountered in rearing adults from hosts which exhibit definite resistance to the development of the parasite larvae. Two hundred and sixty-five adult parasites reared from *Ps. gahani* required an average of 27.79 days to complete their development, 435 adults reared from *Ph. solani* required an average of 29.72 days and 42 adults reared from *Ps. maritimus* required an average of 36.45 days. These data are presented graphically in Figure 1. Only two female adults of the parasite were reared from *Ps. citri* throughout these investigations, and one of these required 43 days to complete its development.

Leptomastix dactylopii larvae require a shorter length of time to complete their development within *Ps. citri* than within any of the other hosts studied. Three hundred and seventy-eight adults reared from *Ps. citri* required an average of 19 days to complete their development from egg to adult, 92 adults reared from *Ps. longispinus* required an average of 24.9 days (Figure 2). These parasites were reared under comparable laboratory conditions.

It was noted from dissection studies, made at definite intervals after parasitization, that parasite larvae developing within *Ps. citri* were

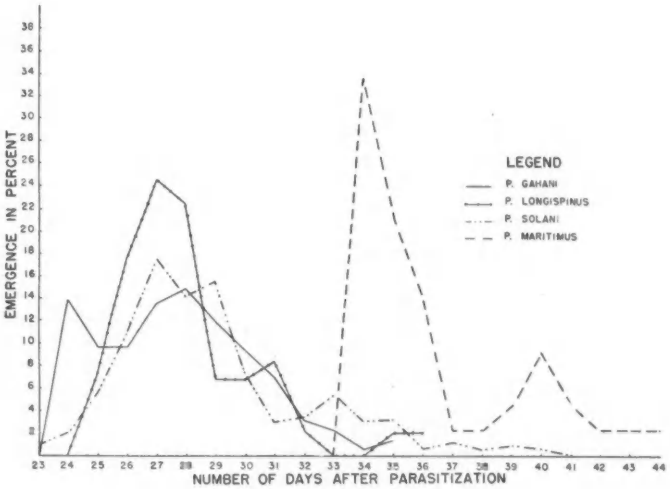

Fig. 1. Length of developmental period of *Coccophagus gurneyi* in different host species.

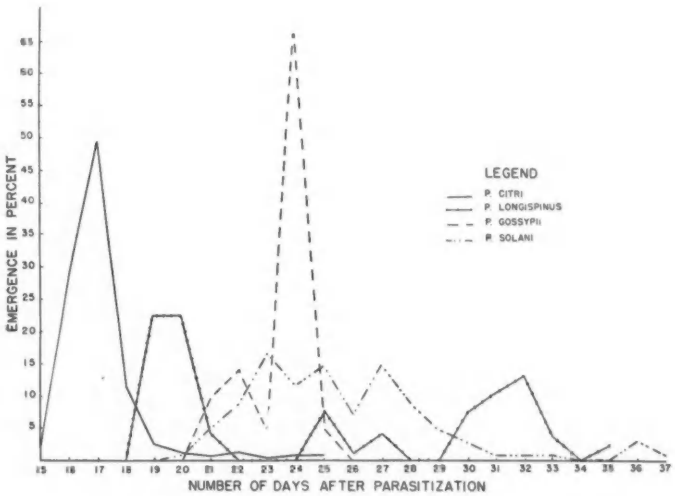

Fig. 2. Length of development period of *Leptomastix dactylopii* in different host species.

noticeably larger than those developing within other species. Further, adults which emerged from *Ps. citri* were noticeably larger than those which emerged from other hosts.

Differences in the developmental rate of parasite larvae within different host species may be influenced by the suitability of the hosts as developmental media. It was not unusual to have parasitized mealybugs complete their development and deposit a large number of eggs before they died. Actually a large number of such individuals might properly be classed as immune, or highly resistant to the parasite, although they contained living parasites at the time of death. Since unparasitized mealybugs usually died within a short time after depositing their eggs or young, the death of a number of those parasitized might well have been a result of senesence.

Probably some parasitic species are unable to develop in certain host species due to the lack of synchronization in the developmental rate of the parasites within the hosts.

SUPERPARASITISM AND PHAGOCYTOSIS

Supernumerary parasite eggs and larvae may or may not become phagocytized within hosts susceptible to the development of the parasite. Phagocytized supernumerary eggs and larvae appear similar to phagocytized solitary eggs or larvae within the respective hosts, and it seems logical to suppose that probably the same phenomenon is involved in the phagocytosis of both solitary and supernumerary individuals.

Coccophagus gurneyi. Five hundred and ninety-five superparasitized mealybugs, representing the six species used throughout these studies, were dissected nine days after parasitization by *C. gurneyi.* A total of 2,807 eggs and larvae of the parasite were in these mealybugs, 514 of which were alive. Some mealybugs contained only living parasites, others only dead ones, and others contained living and dead parasites. Of the 2,293 dead parasites 1317, or 57 percent, were phagocytized, and 976 were not. These data show that large numbers of the parasite eggs and larvae are phagocytized, as well as not phagocytized. However, each host species must be considered separately to interpret these data properly. For instance, all of the 513 dead parasites within *Ps. maritimus* were phagocytized, as compared to only four phagocytized out of a lot of 663 dead parasites within *Ph. solani.* The dead parasites within the other host species were as follows: 452 phagocytized, six not phagocytized within *Ps. citri*; 195 phagocytized, 33 not phagocytized within *Ps. gahani*; seven phagocytized, 230 not phagocytized within *Ps. longispinus*; and 42 phagocytized and 17 not phagocytized within *Ps. gossypii.*

From dissections made 4 to 30 days after parasitization, only 18 living larvae, or about two percent of 938 living larvae (within mealybugs containing more than one parasite egg or larva) were phagocytized. All of those phagocytized were in *Ps. gahani* or *Ph. gossypii*

Leptomastix dactylopii.—Two hundred and eighty-five superparasitized mealybugs, composed of six different species, were dissected seven days after parasitization by *L. dactylopii.* These mealybugs contained 645 parasites, 209 of which were alive, and two, or about one

percent of those alive were phagocytized. Three hundred and nineteen of the dead parasites were phagocytized and the other 117 dead ones were not. The dead parasites within the different species were as fol-

TABLE VIII

PHAGOCYTOSIS OF DEAD SOLITARY AND SUPERNUMERARY EGGS AND LARVAE WITHIN MEALYBUGS FOUR TO FORTY-FOUR DAYS AFTER PARASITIZATION

HOST SPECIES	SOLITARY EGGS AND LARVAE			SUPERNUMERARY EGGS AND LARVAE		
	No. Phag.	No. not Phag.	Percent Phag.	No. Phag.	No. not Phag.	Percent Phag.
Coccophagus gurneyi Compere						
Ps. gahani	37	17	68.5	264	31	89.4
Ps. citri	120	6	95.2	911	6	99.3
Ps. longispinus	3	19	13.6	118	425	21.7
Ps. maritimus	148	3	98.0	1593	5	99.6
Ph. gossypii	248	122	67.0	416	121	77.4
Ph. solani	20	66	23.2	10	706	1.3
Leptomastix dactylopii Howard						
Ps. citri	0	5	0.0	7	119	5.5
Ps. gahani	148	4	97.3	183	4	97.8
Ps. longispinus	236	50	82.5	124	83	59.9
Ps. maritimus	123	0	100.0	184	0	100.0
Ph. gossypii	158	11	93.4	79	20	79.7
Ph. solani	29	12	70.7	32	16	66.6

TABLE IX

PHAGOCYTOSIS OF LIVING SOLITARY AND SUPERNUMERARY LARVAE WITHIN MEALYBUGS FOUR TO THIRTY DAYS AFTER PARASITIZATION

HOST SPECIES	SOLITARY LARVAE			SUPERNUMERARY LARVAE		
	No. Phag.	No. not Phag.	Percent Phag.*	No. Phag.	No. not Phag.	Percent Phag.*
Coccophagus gurneyi Compere						
Ps. gahani	0	123	0	11	294	3
Ps. citri	0	91	0	0	95	0
Ps. longispinus	0	105	0	0	179	0
Ps. maritimus	0	24	0	0	62	0
Ph. gossypii	0	196	0	7	119	5
Ph. solani	0	170	0	0	171	0
Leptomastix dactylopii Howard						
Ps. citri	0	95	0	0	344	0
Ps. gahani	9	5	65	2	7	20
Ps. longispinus	0	71	0	3	168	2
Ps. maritimus	0	1	0	0	1	0
Ph. gossypii	2	37	5	1	10	10
Ph. solani	0	83	0	0	36	0

*Percentages given are in round numbers.

lows: two phagocytized, 34 not phagocytized within *Ps. citri*; 61 phagocytized, none not phagocytized within *Ps. gahani* (there were only four of them living, and two of these were phagocytized); 57 phagocytized, 73

not phagocytized within *Ps. longispinus*; 151 phagocytized, none not phagocytized within *Ps. maritimus*; 31 phagocytized, nine not phagocytized within *Ph. gossypii* and 17 phagocytized and one not phagocytized within *Ph. solani*.

Additional quantitative data are given on both parasites in Tables VIII and IX, which elucidate even further that more of the dead supernumerary, as well as solitary eggs and larvae are phagocytized in some host species than in others.

ROLE OF PHAGOCYTES IN THE RESISTANCE OF MEALYBUG TO PARASITISM

The data obtained from these studies are inadequate to warrant definite conclusions as to the part played by phagocytes in host resistance. In some host species the parasite larvae that die are seldom phagocytized, while in others, apparently healthy eggs and larvae are often completely surrounded by large numbers of phagocytes and, as far as could be ascertained, such eggs and larvae eventually die before larval development is complete. However, it is conjectural as to whether such phagocytes have any direct detrimental effect on the living parasites they surround. The indications are that phagocytosis is not a primary factor in immunity but independent of it.

SUMMARY

Comparatively few experimental data are available on the resistance of insect hosts to entomophagus parasites, and even fewer on the relation of phagocytosis to immunity. However, several workers have called attention to these phenomena and presented a limited amount of information on them.

The following have been observed or demonstrated by former workers:

(1) Formation of dense phagocytic cysts around living and dead parasite eggs and larvae, as well as around a number of inert materials. However, in certain species the encapsulated living eggs and larvae continued their development and transformed into adults.

(2) Retardation of the rate of development of the parasite larvae in certain hosts.

(3) Encystment of parasite eggs introduced into host larvae which were practically ready to transform into pupae, while the eggs deposited in immature larvae were free from attack.

(4) Destruction of the first two thoracic ganglia did not affect immunity, but the destruction of the third thoracic ganglion did affect it (bacteria were the organisms used).

(5) A host normally immune to a specific parasite was made susceptible by parasitization by another parasite to which it was susceptible.

There are two principal viewpoints regarding the nature of the resistance or immunity exhibited by insect hosts to entomophagus parasites. One of these is that phagocytes attack living eggs and larvae, and thus play a primary part in causing their death. The other is that immunity is based on some humoral phenomenon, and that phagocytes merely act as scavengers, protecting the host against injury from unhealthy and dead parasite eggs and larvae. However, some immunologists consider that serum lysis and destruction by true phagocytosis (intracellular) are essentially the same, and that in either case there is a specific antibody sensitization (opsonization) which prepares the invading parasite for lysis, either inside or outside of the cells that furnish the lytic enzymes. Since lysis and phagocytosis may be considered as expressions of the same mechanism, there is probably no fundamental distinction between so-called humoral and cellular immunity, both of which are expressions of the cellular reactions of the host.

Other hypotheses suggested as possible causes of immunity are: (a) formation of melanistic substances around parasite, (b) enzymatic lysis, (c) liberation of active substances by the host which are detrimental to the parasite (perhaps this hypothesis, the preceding one, and the one concerning serum lysis overlap), (d) improper nutrition received by the developing parasite, (e) lack of fat body in host (probably insufficient food), and (f) incompatibility of protoplasm.

It has been suggested that the death of supernumerary larvae is initiated by the oldest parasite larvae by either (a) mechanical injury, or (b) cytolytic enzymes secreted at the time

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EXPLANATION OF PLATE

Fig. 1. Longitudinal section through a cyst formed around *L. dactylopii* within *Ps. gahani* (72 hours after parasitization).

Fig. 2. Section of same enlarged.

Fig. 3. Longitudinal section through a cyst formed around *L. dactylopii* within *Ps. maritimus* (48 hours after parasitization).

Fig. 4. Section of same enlarged.

Fig. 5. Partially encapsulated living larva of *C. gurneyi* within *Ph. gossypii* (13 days after parasitization).

Fig. 6. Encapsulated egg or small larva of *C. gurneyi* within *Ph. gossypii* (13 days after parasitization).

Fig. 7. Encapsulated larva of *C. gurneyi* within *Ph. gossypii* (13 days after parazitization).

KEY TO ABBREVIATIONS

D.—Derm of host.
Em.—Embryo of parasite.
F. M.—Fibrous mass.
M. L.—Melanized layer.
M. S.—Melanized sheath.
Pa.—Parasite.

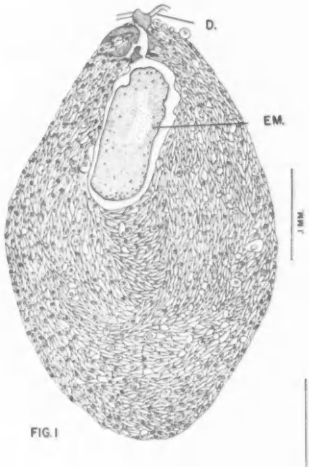

FIG. 1

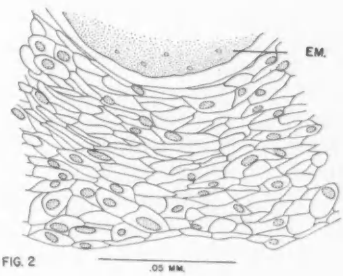

FIG. 2

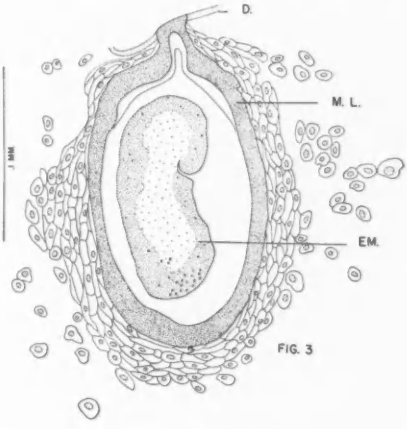

FIG. 3

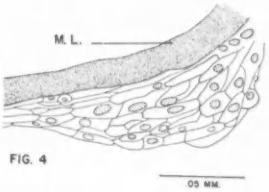

FIG. 4

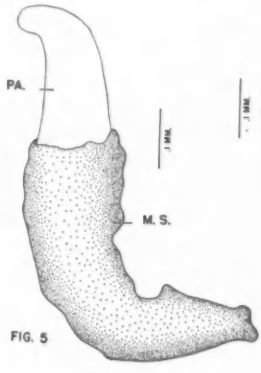

FIG. 5

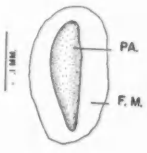

FIG. 6

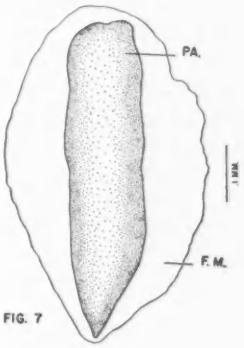

FIG. 7

of hatching, which bring about the degeneration of larvae that hatch later.

The experimental data presented in this paper are largely quantitative, and relate to the resistance exhibited by six species of mealybugs to the development of two internal hymenopterous parasites within these hosts. The following observations were made:

(1) Differences existed in the degree of attractiveness of the different host species to the adult parasites for oviposition.

(2) Two of the species of mealybugs were apparently free from successful parasitization by *L. dactylopii;* and varying degrees of susceptibility or immunity were exhibited by the different host species to both parasites.

(3) The developmental rate of a parasite may be influenced by the host species in which it develops.

(4) Eggs and larvae which die before transforming into adult parasites succumb earlier in some hosts than in others. In *Ps. maritimus* these dead parasites are usually surrounded by melanized sheaths, while in *Ps. gahani* they may remain alive for some time within phagocytic cysts, but eventually the cysts are melanized.

(5) In some resistant hosts the parasite eggs and larvae which are unable to complete their development become enveloped by a dense phagocytic cyst, while in other hosts such eggs and larvae are seldom phagocytized.

(6) Supernumerary parasite eggs and larvae are phagocytized in some hosts and not in others.

(7) The phagocytic cysts formed around parasite eggs and larvae in different hosts differ somewhat in structure. Encystment of the eggs of either parasite ensued at about the same time in different host species, but the eggs of *L. dactylopii* were usually phagocytized within 48 to 60 hours after deposition, while the eggs of *C. gurneyi* were not phagocytized until 72 hours or more after deposition. Phagocytosis of the eggs of both parasites usually occurred about the time of hatching. Therefore, the time that the encystment of the eggs occurred was determined by the incubation period.

CONCLUSIONS

1. Host specificity, insofar as oviposition is concerned, depends upon the attractiveness of the hosts to the female adults and not upon the suitability of the hosts as media for the development of their progeny.

2. Differences in the developmental rate of a parasite within different hosts, as well as the resistance of these hosts, may well be due in part to the favorability of the host fluids as nutriment.

3. The unsuitability of a resistant or immune host as a developmental medium for a specific parasite may be due to something (enzyme, etc.) lacking or possessed by the parasite rather than something lacking or possessed by the host. Therefore, immunity should probably be considered in terms of the parasite as well as the host.

4. Apparently the stimulus which initiates phagocytosis of the parasite eggs in *Ps. gahani* and *Ps. maritimus* is associated in some way with the development of the parasite larvae within the eggs. There is some evidence, although not conclusive, that phagocytosis of the parasite eggs in these species was initiated by chemical substances liberated about the time of hatching.

5. The difference between immunity and susceptibility is not a qualitative difference, but a quantitative one.

6. Parasites die earlier in some resistant or immune hosts than in others. Superficially, it appears that the rapidity of melanization may be a factor in causing the death of parasites in certain hosts. However, we are not certain whether melanization is a primary defense reaction or not.

7. None of the following alone appears adequate to explain how immunity is realized: (a) phagocytosis, (b) character of surface of parasite, (c) hosts inadequate as food, or (d) melanization.

8. What is the role of phagocytosis in the resistance of mealybugs to parasitization by *C. gurneyi* and *L. dactylopii?* The data obtained do not present an adequate answer to this question. However, they show that *immunity is not necessarily accompanied by phagocytosis*. When present, phagocytosis could possibly result in increasing the amount of chemical substances around the parasite, which may be responsible for its destruction. The retardation of the rate of development and the death of larvae in resistant hosts in the absence of phagocytosis tend to indicate that resistance is a phenomenon independent of phagocytosis.

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25. ———. 1930b. Reaction of the phagocytes of Arthropods to their internal insect parasites. Nature 125 (3154): 565–566.
26. ———. 1934. The tachinid parasites of woodlice. Parasitology 26 (3): 378–448.
27. **Thorpe, W. H.** 1936. On a new type of respiratory interrelation between an insect (Chalcid) parasite and its host (Coccidae). Parasitology 28 (4): 517–540.
28. **Timberlake, P. H.** 1912. Experimental Parasitism. A study of the biology of *Limnerium validum* Cresson. U. S. D. A., Bur. Ent., Ser. 19: 71–92.
29. **Wells, H. G.** 1925. The Chemical aspects of immunity. Amer. Chem. Soc. Mono. Ser. Chem. Cat. Co., Inc., New York.

ENTOMOLOGICAL SOCIETY OF AMERICA

PROCEEDINGS OF THE THIRTY-THIRD ANNUAL MEETING

Richmond, Virginia, December 27-29, 1938

The Entomological Society of America held its Thirty-third Annual Meeting on Tuesday, Wednesday and Thursday.

A joint symposium was held on Tuesday afternoon with the American Association of Economic Entomologists and the Ecological Society of America on "Insect Populations." It was pointed out in this symposium that the problem of insect populations is a fundamental one for the field of economic entomology and that all problems connected with outbreaks of insects are related to this basic problem of populations. The subject matter of the symposium was presented from several viewpoints, namely, in relation to insect outbreaks, to soil insects, to forest insects, to social insects, and to the problems of the biological control of insects. There was a long discussion after the papers had been presented and it is hoped that one result will be the stimulation and expansion of work in this more or less neglected field.

The Annual Public Address was given by Professor C. T. Brues, of Harvard University, on the subject "Food, Drink and Evolution," following the Entomologists' Dinner on Wednesday night. Professor Brues discussed the evolutionary development of food habits among the insects, pointing out the differences in evolutionary trends with respect to this character among various groups of insects, and sometimes comparing them with the food habits of man.

The program presented at the three days meeting follows:

Opening Session, Tuesday Morning, December 27

The Society was called to order at 9:30 A. M. by PRESIDENT A. L. MELANDER in the Washington-Byrd-Lee Room of the HOTEL JOHN MARSHALL. PRESIDENT A. L. MELANDER appointed the following committees:

Nominating Committee—H. B. HUNGERFORD, *Chairman;* R. N. CHAPMAN, E. P. FELT.

Resolutions Committee—C. W. SABROSKY, *Chairman;* B. B. FULTON, G. F. FERRIS.

Auditing Committee—R. C. OSBURN, *Chairman;* A. G. RUGGLES, HOWARD O. DEAY.

The following papers were presented:

Episodes of Insect Behavior. (Motion Pictures in Color.) A. L. MELANDER, City College of New York, New York, New York.

1. Life Histories of *Psorophora columbiae* (Dyar and Knab) and Associated Mosquitoes. (15 min.) (Lantern.) H. H. SCHWARDT, Cornell University, Ithaca, New York.
2. The Male of *Somatochlora georgiana* Walker (Odonata, Cordulinae). (10 min.) (Lantern.) SEPTIMA C. SMITH AND ROBERT S. HODGES, University of Alabama, University, Alabama.

3. Insect Enemies of the San Jose Scale with Special Reference to *Prospaltella perniciosi* Tower. (15 min.) (Lantern.) PAUL L. RICE, Alma College, Alma, Michigan.
4. Effect of Selected Diet on Egg Production and Longevity of *Melanoplus bivittatus* Say. (By title.) OSCAR E. TAUBER, Iowa State College, Ames, Iowa.
5. A Description of the Larva of *Ludius divaricatus* Leconte. (10 min.) (Lantern.) H. H. JEWETT, Agricultural Experiment Station, Lexington, Kentucky.
6. An Apparently New Genus and Species of Dermestidae. (10 min.) H. E. MILLIRON, University of Minnesota, St. Paul, Minnesota.
7. Entomological Etymology. (12 min.) A. L. MELANDER, College of the City of New York, New York, New York.
8. The Thoracic Nervous System of a Grasshopper. (15 min.) (Lantern.) JOHN B. SCHMITT, New Jersey Agricultural Experiment Station, Trenton, New Jersey.
9. The Role of the Spermatheca in Sex Determination. (15 min.) STANLEY E. FLANDERS, Citrus Experiment Station, Riverside, California.

The Society then adjourned to meet with the AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS to hear the address of their president, PROFESSOR J. J. DAVIS.

Second Session, Tuesday Afternoon, December 27

Joint Session with AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS, and ECOLOGICAL SOCIETY OF AMERICA.

Symposium: "Insect Populations."

The session was called to order by DR. V. E. SHELFORD at 2:30 P. M. and the following papers were presented:

Insect Population Problems in Relation to Insect Outbreaks. ROYAL N. CHAPMAN, Director, Pineapple Producers' Experiment Station, Honolulu, Hawaii.

Population Studies of Soil Insects. KENNETH M. KING, Dominion Entomological Laboratory, Saskatoon, Saskatchewan, Canada.

Populations of Social Insects. ALFRED E. EMERSON, Department of Zoology, University of Chicago, Chicago, Illinois.

Forest Insect Populations. SAMUEL A. GRAHAM, School of Forestry and Conservation, University of Michigan, Ann Arbor, Michigan.

Insect Populations in Relation to Biological Control. HARRY S. SMITH, Citrus Experiment Station, University of California, Riverside, California.

PRESIDENT A. L. MELANDER appointed the following to act as alternates for absent members of the Executive Committee, which met at 7:00 P. M. Tuesday: R. E. SNODGRASS, C. T. BRUES.

Third Session, Wednesday Morning, December 28

The Society was called to order at 9:30 A. M. by PRESIDENT MELANDER and the following papers were presented:

Episodes of Insect Behavior. (Motion Pictures in Color.) A. L. MELANDER, City College of New York, New York, New York.

10. Does Mimicry Work Both Ways? (15 min.) (Lantern.) Z. P. METCALF, State College Station, Raleigh, North Carolina.
11. A Revision of the Genus *Xestoblatta* Hebard, with notes on Certain Special Glands of Orthoptera. (15 min.) (Lantern.) ASHLEY B. GURNEY, Bureau of Entomology and Plant Quarantine, Washington, D. C.

12. Nutritional Studies of the Confused Flour Beetle, *Tribolium confusum* Duval, and the Bean Weevil, *Acanthoscelides obtectus* (Say). (10 min.) (Lantern.) SHIN FOON CHIU AND C. M. MCCAY, Cornell University, Ithaca, New York.
13. Effect of Temperature upon the Oxygen Requirements of Adult Female Citrus Mealybugs and of Eggs of the Spotted Milkweed Plant Bug. (15 min.) (Charts.) VIRGIL N. ARGO, College of the City of New York, New York, New York.
14. Observations of Factors Affecting Total Weight and Total Moisture of Corn Earworm Pupae. (15 min.) (Lantern.) L. P. DITMAN AND JOHN H. GUILL, University of Maryland, College Park, Maryland.
15. Effect of Ingested Glucose on Blood and Tissue Glucose and Glycogen of the Larval Southern Armyworm, *Prodenia eridania* Cram. (10 min.) (Lantern.) FRANK H. BABERS, Bureau of Entomology and Plant Quarantine, Beltsville, Maryland.
16. Glycogen in Blood and Intestinal Cells of the Southern Armyworm, *Prodenia eridania* Cram., with Reference to Apparent Effects of Some Insecticides. J. FRANKLIN YEAGER, Bureau of Entomology and Plant Quarantine, Beltsville, Maryland.
17. Differential Growth in the Mexican Bean Beetle, *Epilachna varivestis* Muls. (15 min.) (Lantern.) NELLIE M. PAYNE, American Cyanamid Co., Stamford, Connecticut.

Fourth Session, Wednesday Afternoon, December 28

Following the call to order at 2:00 P. M. by PRESIDENT MELANDER the following papers were presented:

18. The Embryology of *Prodenia eridania* Cram. (Noctuidae). (5 min.) (Lantern.) JAMES B. GROSS, New York University, New York, New York.
19. The Lemna Fly and Some of Its Parasites. (10 min.) (Lantern.) MINNIE B. SCOTLAND, State College, Albany, New York.
20. Progress Towards a Collection of Mallophaga from all North American Host Species. (10 min.) F. H. WILSON, Tulane University, New Orleans, Louisiana.
21. Respiratory Metabolism during Larval and Pupal Development of the Female Honeybee (*Aphis mellifica* L.) (12 min.) (Lantern.) R. M. MELAMPY, Bureau of Entomology and Plant Quarantine, University, Louisiana.
22. The Mating and Egg-Laying of *Malacosoma americana*. (15 min.) JOSEPH L. WILLIAMS, Lincoln University, Pennsylvania.
23. Chinch Bug Abundance from 1823 to 1938. (10 min.) (Lantern.) V. E. SHELFORD AND W. P. FLINT, University of Illinois, Urbana, Illinois.
24. The Life Cycle and the Differentiation and Development of the Castes of Termites. (15 min.) (Lantern.) OLIVE FALLS, State Teachers College, St. Cloud, Minnesota.
25. Fungus-growing Ants of Barro Colorado Island: Their Habits, Nests and Guest Ants. (12 min.) (Lantern.) NEAL A. WEBER, University of North Dakota, Grand Forks, North Dakota.
26. Biology and Ecology of a Fungus-cultivating Ant of the Mississippi Gulf Coast. (15 min.) (Lantern.) A. C. COLE, JR., University of Tennessee, Knoxville, Tennessee.

Fifth Session, Wednesday Evening, December 28

Following the Entomologists' Dinner, PRESIDENT A. L. MELANDER introduced PROFESSOR C. T. BRUES, who gave the Annual Public Address on the subject, "Food, Drink and Evolution."

Sixth Session, Thursday Morning, December 29

The Society was called to order at 9:30 A. M. by PRESIDENT MELANDER and the following papers were presented:

Episodes of Insect Behavior. (Motion Pictures in Color.) A. L. MELANDER, City College of New York, New York, New York.

27. The Mode of Shedding the Tracheal Trunks of Insects. (10 min.) (Lantern.) L. E. HAGMANN, New Brunswick, New Jersey.
28. Anatomy and Histology of the Alimentary Tract of *Locusta migratoria* L. CHARLES HODGE, 4th, Temple University, Philadelphia, Pennsylvania.
29. Rearing the Caddis-fly *Limnephilus indivisus* Walker and Its Hymenopterous Parasite *Hemiteles* sp. (15 min.) (Lantern.) CLARENCE E. MICKEL AND H. E. MILLIRON, University of Minnesota, St. Paul, Minnesota.
30. High Speed Photographs and Motion Pictures of Insect Flight. (15 min.) (Lantern and Motion Pictures.) LEIGH E. CHADWICK, Cambridge, Massachusetts.
31. A New Species of *Sialis* from Kentucky (Megaloptera, Sialidae). (8 min.) (Lantern.) LEE H. TOWNSEND, University of Kentucky, Lexington, Kentucky.
32. The Genus *Athysanella* and Related Genera (Homoptera, Cicadellidae). (10 min.) (Lantern.) R. H. BEAMER, University of Kansas, Lawrence, Kansas.

The above meetings were attended by about 225, of whom 157 registered with the Secretary.

The following is a report of the Annual Business Meeting which was held Thursday morning, December 29.

REPORT OF THE SECRETARY

During the year 1938, the following having been duly nominated and recommended were elected members of the Society by mail ballot of the Executive Committee:

PETER I. BRYCE, Vineland Station, Ontario, Canada.
PAUL A. DAHM, 502 East John St., Champaign, Illinois.
CHARLES B. EATON, 335 Giannini Hall, University of California, Berkeley, California.
JAMES FORBES, Dept. Biology, Fordham University, New York, New York.
EDWARD S. HATHAWAY, Tulane University, New Orleans, Louisiana.
CHARLES HODGE, 4th, Dept. of Biology, Temple University, Philadelphia, Pennsylvania.
LEE R. JEPPSON, 335 N. Third E., Logan, Utah.
RAYMOND E. LOWRIE, 48 State St., New Bedford, Massachusetts.
DANIEL LUDWIG, New York University, New York, New York.
PHILIP H. MARVIN, Division of Entomology, University Farm, St. Paul, Minnesota.
STANLEY D. MIROYIANNIS, Department of Biology, Northeastern University, Boston, Massachusetts.
JAMES A. MULLEN, Department of Biology, Fordham University, New York, New York.
LOWELL E. NOLAND, Department of Zoology, University of Wisconsin, Madison, Wisconsin.
MURL B. SAILSBURY, Fisher, Illinois.
HAROLD M. STEINER, Arendtsville, Pennsylvania.
C. WILLEMSE, Eygelshoven, Z. L., Holland.
ALFRED ZIMMERN, 5007 Lindsley Ave., Dallas, Texas.

With the approval of the Executive Committee, Richmond, Virginia, was selected as the place for holding the thirty-third annual meeting after negotiations with the Permanent Secretary of the American Association for the Advancement of Science.

With the approval of the Executive Committee a joint symposium on the subject "Insect Populations" was arranged for with the American Association of Economic Entomologists and the Ecological Society of America.

MR. W. D. REED kindly consented to act as chairman of the local committee on arrangements at Richmond to represent both entomological societies and was so appointed by PRESIDENT MELANDER. DR. J. W. BAILEY and MR. HARRY G. WALKER also represented the Entomological Society of America on this committee. DR. W. J. SCHOENE was appointed by the PRESIDENT to co-operate with DR. G. T. FRENCH, of the American Association of Economic Entomologists in arranging and supervising the exhibits of the Society at the Richmond meeting.

The SECRETARY met with PROFESSOR W. P. FLINT, the Chairman of the Program Committee of the American Association of Economic Entomologists, and DR. ORLANDO PARK, Secretary of the Ecological Society of America, at Chicago, Illinois, on March 23, 1938, and arranged a joint symposium for the Richmond meeting.

With the approval of the Executive Committee PROFESSOR C. T. BRUES was invited to give the Annual Public Address of the Society at the Richmond meeting.

The Society co-operated with the Entomological Society of Ontario in presenting a program of entomological subjects at the Ottawa meeting of the American Association for the Advancement of Science.

PRESIDENT MELANDER appointed DR. O. A. JOHANNSEN as delegate, and DR. A. AVINOFF as associate delegate to the Seventh International Entomological Congress at Berlin, Germany.

The executive committee by mail ballot authorized the transfer of $500.00 from the Permanent Fund to the Current Fund to assist in the publication of the 1938 volume of the Annals.

PRESIDENT MELANDER represented the Society at the Seventy-fifth Anniversary meeting of the Entomological Society of Ontario.

The Executive Committee voted by mail ballot to increase the price of the Annals to non-member subscribers from $4.00 to $5.00.

The Executive Committee met at 7:30 P. M., December 28, in the Hotel John Marshall, Richmond, Virginia, the following officers being present: A. L. MELANDER, W. D. FUNKHOUSER, C. F. W. MUESEBECK, CLARENCE E. MICKEL. Two other members of the committee were present: S. A. GRAHAM and R. C. OSBURN. The following alternates designated by the PRESIDENT, served in place of absent members of the committee: C. T. BRUES, R. E. SNODGRASS. The following were elected to membership in the Society:

CHARLES H. BALLOU, Estacion Experimental de Agricultura y Zootecnia, El Valle, Distrio Federal, Venezuela.

WILLIAM F. BICKLEY, JR., University of Maryland, College Park, Maryland.

RALPH W. BUNN, 720 West Jackson, Medford, Oregon.

HAMBLIN H. CROWELL, Department of Zoology and Entomology, Ohio State University, Columbus, Ohio.

ALFRED C. CURTIS, 1127 Valtier St., Manhattan, Kansas.

PAUL H. DEBACH, Citrus Experiment Station, Riverside, California.

IRVING B. DOBKIN, 3435 W. Eighteenth St., Chicago, Illinois.

MARCEL DROLET, 95 Ste. Foy Road, Quebec, Quebec, Canada.

K. C. EMERSON, Department of Entomology, Oklahoma A. and M. College, Stillwater, Oklahoma.

ERWIN J. EPSTEIN, 3264 Cedarbrook Road, Cleveland Heights, Ohio.

CARL FILSINGER, 1114 Grandview Ave., Westfield, New Jersey.

BRUCE D. GLEISSNER, Department of Zoology and Entomology, Ohio State University, Columbus, Ohio.

LEONARD HANSEN, Department of Entomology, Utah Agricultural College, Logan, Utah.

ORVILLE B. HITCHCOCK, Department of Entomology, Montana State College, Bozeman, Montana.

HARRY HOOGSTRAAL, 304 Entomology Bldg., University of Illinois, Urbana, Illinois.

RAY HUTSON, Department of Entomology, Michigan State College, East Lansing, Michigan.

F. L. JAMES, 807 Flower Ave., Tacoma Park, Maryland.
ALEXANDER B. KLOTS, 17 Lexington Ave., New York, New York.
NOAL P. LARSON, Department of Entomology-Zoology, South Dakota State College, Brookings, South Dakota.
JUSTIN W. LEONARD, Institute for Fisheries Research, Ann Arbor, Michigan.
FREDERICK W. MALLY, 1627 W. Huisache Ave., San Antonio, Texas.
RALPH B. MARCH, 303 Entomology Bldg., University of Illinois, Urbana, Illinois.
J. W. MONK, Hacienda de Santa Engracia, Santa Engracia, Tamaulipas, Mexico.
B. D. W. MORLEY, Holy Trinity Vicarage, Madeira Road, Bournemouth, England.
H. PAGE NICHOLSON, Division of Entomology, University Farm, St. Paul, Minnesota.
MAURICE E. PHILLIPS, Hanshaw Road, Ithaca, New York.
FRANK M. SEMANS, 1725 McCollum Road, Youngstown, Ohio.
HORACE J. SHIPMAN, Bureau of Entomology and Plant Quarantine, Bozeman, Montana.
JOSEPH M. SINGLETON, 308 Customhouse, New Orleans, Louisiana.
FRED E. SKOOG, Bureau of Entomology and Plant Quarantine, Bozeman, Montana.
SEPTIMA C. SMITH, Box 1446, University, Alabama.
KATHRYN M. SOMMERMAN, Department of Entomology, University of Illinois, Urbana, Illinois.
GEORGE S. STAINS, Department of Entomology, Utah Agricultural College, Logan, Utah.
LOYD L. STITT, Tempe, Arizona.
JOSEPH B. TUCK, 1110 Kearney St., Manhattan, Kansas.
GEORGE E. WALLACE, Department of Entomology, Carnegie Museum, Pittsburgh, Pennsylvania.
JOSEPH L. WILLIAMS, Box 90, Lincoln University, Pennsylvania.
HAROLD R. WILLIS, Department of Entomology, Montana State College, Bozeman, Montana.

The total number of new members for the year 1938 is 55.

The following have resigned during the year: O. G. BABCOCK, W. A. BAKER, WM. BEEBE, THOMAS P. CASSIDY, WALLACE COLMAN, W. S. CORKRAN, DEREK H. CROSS, CLIFTON J. DAVIS, R. W. DOANE, C. K. FISHER, G. H. GEISSLER, HARRY L. GUI, D. M. HAMMOND, WALTER N. HESS, L. A. HETRICK, GALEN A. HINKLE, EDWIN W. HOWE, S. E. JONES, H. Y. KIM, E. W. LAAKE, HORACE LANCHESTER, JOSEPH N. LANG, PHILIP LAURENT, H. J. MACALONEY, G. ALLEN MAIL, WARREN C. MILLER, H. K. MUNRO, W. W. NEWCOMB, LESLIE W. ORR, OWEN S. PAXSON, W. A. SIMANTON, OSGOOD R. SMITH, DAYTON STONER, RUTH SUMNER, NATHANIEL TISCHLER, CLAUDE WAKELAND, F. E. WHITEHEAD, FORREST B. WHITTINGTON.

The following have been automatically dropped from membership either because of failure for three or more years to pay dues or because they cannot be reached: R. E. BARRETT, J. M. BRENNAN, FRED D. BUTCHER, CLIFFORD L. DICKINSON, H. E. GUTHRIE, GEORGE E. SANDERS.

The Executive Committee elected the following FELLOWS: E. A. BACK, F. M. CARPENTER, WALTER CARTER, JOSEPH C. CHAMBERLIN, F. R. COLE, WM. C. COOK, P. J. DARLINGTON, JR., J. R. EYER, STANLEY B. FREEBORN, ROGER B. FRIEND, F. M. GAIGE, PHILIP GARMAN, HAROLD R. HAGEN, MELVILLE H. HATCH, H. C. HUCKETT, KENNETH M. KING, WILLARD V. KING, E. A. MCGREGOR, A. GLENN RICHARDS, JR., M. R. SMITH, P. H. TIMBERLAKE, H. F. WILLARD.

The Society has suffered loss by death of the following four members during the past year: FREDERICK C. GILLIATT, WILLIAM E. RUMSEY, FREDERICK W. URICH, and R. A. VICKERY.

FREDERICK COURTENAY GILLIATT, a member of our Society since 1928, was born in Granville Centre, Annapolis County, Nova Scotia, in 1889. He graduated from the Nova Scotia Agricultural College in 1910. After several years' work with the Nova Scotia Provincial Department of Agriculture, principally on the Brown Tail Moth and San Jose Scale, he received a permanent appointment at the Dominion Entomological Laboratory, Annapolis Royal, Nova Scotia. In recent years his health had been poor but shortly before his death he appeared much improved, so that his death on April 28, 1938, was a shock to his friends and associates. In 1919 he was married to HORTENSE V. B. SPURR, who with his daughter HORTENSE MARIE, aged 18, and son SHIPPY COURTENAY, aged 16, were left to mourn his death. Mr. Gilliatt was somewhat reserved, but was unusually

persistent and extraordinarily observant, both of which qualities enabled him to make valuable contributions towards the solution of problems concerned with the control of insects attacking fruit. His interest in orcharding was not confined to the insect pests of fruits, but extended to the growing of fruits, which he practiced in an extensive plantation of pears, peaches, cherries and plums. In his death his friends, neighbors and professional colleagues have lost a sympathetic friend and a valuable entomological worker.

WILLIAM EARL RUMSEY, a charter member of our Society, was born in Van Etten, New York, on September 9, 1865, and died at Morgantown, West Virginia, February 16, 1938. He was a student of Professor Comstock at Cornell University, from which institution he graduated in 1891. He went to the West Virginia Experiment Station in 1893, where he later became entomologist of the Station and finally State Entomologist. At the time of his death he was the oldest member on the staff and had completed forty-five years of continuous service. As State Entomologist he became widely acquainted with the people of West Virginia and in spite of the duties which were sometimes disagreeable and onerous he not only won their confidence and co-operation but also secured their active support for the Experiment Station. His wife, STELLA BERKSHIRE RUMSEY, a son, NEALE O. RUMSEY, and a daughter, VIRGINIA RUMSEY NEY, survive him.

FREDERICK WILLIAM URICH, a member of our Society from 1918 to 1936, died at his home in Port-of-Spain, Trinidad, on June 22, 1937. His formal education was obtained in Germany and Switzerland. For many years his interest in entomology was only an avocation but his accomplishments in this field gained him recognition and in 1920 he was appointed Entomologist of the Department of Agriculture of Trinidad and Tobago. In 1926 he was made Assistant Professor of Zoology at the Imperial College of Agriculture in Trinidad, a post which he held until 1935. Shortly before his death he resigned his membership in our Society due to a long continued illness.

ROY ALBION VICKERY, a charter member of our Society, was born at Mora, Minnesota, March 15, 1883. He attended the University of Minnesota where he received the degree of bachelor and master of arts. He was connected with the Bureau of Entomology and Plant Quarantine for about thirty years and at the time of his death was serving with the Division of Pink Bollworm Control. He died at San Antonio, Texas, July 13, 1938. He is survived by a sister, three nephews and a niece.

Following the reading of these brief memorials the members stood in silence in memory of the four who have died during the past year.

The total membership on December 31, 1938, is 949.

The following were elected to the Editorial Board of the Annals for the three-year term ending December 31, 1941: F. M. CARPENTER, C. L. FLUKE, HARRY B. WEISS.

The following were elected by the Executive Committee to the Thomas Say Foundation Committee for the term expiring December 31, 1940: GEORGE P. ENGELHARDT, JOHN D. SHERMAN, JR.

The Executive Committee voted to contribute $10.00 towards the expenses of the Biologists' Smoker at Richmond, Virginia.

The Executive Committee voted to contribute $50.00 to the Zoological Society of London for the support of the Zoological Record.

The Executive Committee voted to pay the travel expenses of the SECRETARY-TREASURER to the Annual Meetings.

PROFESSOR A. C. KINSEY was appointed by PRESIDENT MELANDER to represent the Society at the Richmond meeting of the Union of American Biological Societies.

The Executive Committee voted to hold the 1939 annual meeting at Columbus, Ohio, at the same time as the meetings of the American Association for the Advancement of Science.

Respectfully submitted,

CLARENCE E. MICKEL, *Secretary.*

On motion the Secretary's Report was accepted and the recommendations of the Executive Committee adopted.

REPORT OF THE TREASURER

Current Funds

RECEIPTS

Balance on hand in bank, December 16, 1937 (see Annals, Vol. 31, p. 122)	$1,014.33
From Annual Dues of Members to December 17, 1938	2,763.35
From Clarence H. Kennedy, Managing Editor of Annals	772.75
Transfer from Permanent Fund to Checking Account	500.00
From two Life Memberships, Rodney H. Dodge and Oscar E. Tauber	100.00
From sale of two membership lists	2.00
Total	$5,152.43

EXPENDITURES

Postage, including 1,000 three-cent stamped envelopes and 1,000 one and one-half cent stamps	$ 52.76
Spahr and Glenn Printing Co., Printing December, 1937, and March, June and Septemper, 1938, Annals	2,496.44
Letterheads for President and Secretary-Treasurer, and stamped envelopes for President	14.00
Printing preliminary announcements, blank forms and programs	111.00
Office Supplies	8.00
Clerical Services	31.60
Biologists' Smoker, Indianapolis Meeting	10.00
Expense of exhibits at Indianapolis Meeting	3.78
Expenses of Secretary in attending meeting at Chicago of joint committee to arrange for Richmond symposium	23.55
Checks returned by bank	15.50
Exchange on checks	30.57
Transfer of Life Membership payments to Permanent Fund, Rodney H. Dodge and Oscar E. Tauber	100.00
Total	$2,897.20
Balance in Checking Account, December 17, 1938	2,255.23
Total	$5,152.43

Liabilities

The Society owes the publishers for the December, 1938, Annals. Of the above cash receipts for dues, $1,319.90 is for 1939 dues.

Permanent Fund

RECEIPTS

Balance in Savings Account, December 16, 1937	$3,356.32
Interest on Savings Account, December 16, 1937, to December 17, 1938	51.02
Interest on Liberty Bond 45554-D	1.44
From two life memberships	100.00
Total	$3,508.78

EXPENDTIURES

Transferred to checking account, as authorized by Executive Committee, June 15, 1938	$ 500.00
Total	$ 500.00
Balance in Savings Account, St. Anthony Park State Bank, St. Paul, Minn	$3,008.78
One Liberty Bond, 45554-D	50.00
Balance in Permanent Fund	$3,058.78

RESOURCES

Liberty Bond 45554-D	$ 50.00
Balance in Savings Account	3,008.78
Balance in Checking Account	2,255.23
Total	$5,314.01

Respectfully submitted,
CLARENCE E. MICKEL, *Treasurer.*

On motion the Treasurer's Report was accepted, subject to the approval of the Auditing Committee.

REPORT OF THE MANAGING EDITOR OF THE ANNALS

I wish to report that 669 pages of material have been published in Volume XXXI for 1938 as against 654 pages for 1937 and 800 pages for 1936. The Executive Committee advanced $500.00 to the ANNALS from the Permanent Fund and the ANNALS has turned a balance on its books of $500.00 over to the Secretary-Treasurer. Thus, apparently, on a membership of $3.00 per year the Society might maintain the ANNALS as a volume of about 600 pages. With the increase of dues to $4.00 and of subscriptions to $5.00 the ANNALS should be a volume of 700 or 800 pages.

We feel that the quality of material offered the ANNALS is increasing from year to year. Fewer offerings of articles have to be returned for lack of quality. More and more physiological articles are coming in. We do not intend to let these crowd out morphology, taxonomy and ecology, but the ANNALS will have to recognize physiological articles as a proper part of its grist. PROFESSOR F. L. CAMPBELL, now Assistant Managing Editor, will check and edit these.

We wish to say a word concerning the work of BIRELY J. LANDIS as ASSISTANT MANAGING EDITOR from January, 1932, to December, 1937. Up to the time of Landis' advent in the work, the Editors had carried their technique and policies in their heads. Landis saw the ANNALS work as a complex of individual minor problems and always sought in each case a solution which would be in approved editorial style. He worked with a dictionary and a battery of style books at hand. The two editors, with the assistance and experience of PROF. HERBERT OSBORN, finally outlined the editorial policies of the ANNALS office in the article "On Writing Articles for the Annals of the Entomological Society of America," (1934). LANDIS is an artist and saw the problems from the point of view of good appearance as well as from a practical point of view. He has left his impress on the ANNALS. We wish to thank him for his continuous efforts.

When MR. LANDIS was put in charge of a federal laboratory at Puyallup, Washington, early in 1938 he had to resign. At this time PROFESSOR F. L. CAMPBELL of the Ohio State University staff, accepted the onerous job of Assistant Managing Editor.

The financial summary follows:

RECEIPTS

Non-member subscriptions	$ 842.32
Sale of back numbers	127.48
From authors for cuts	358.55
Bank Balance from 1937	20.04
Total	$1,348.39

EXPENDITURES

To engravers	$ 323.80
Office help	300.00
Postage	52.52
Miscellaneous	99.40
To Secretary-Treasurer	500.00
Bank Balance, December 15, 1938	72.67
Total	$1,348.39

Respectfully submitted,
CLARENCE H. KENNEDY, *Managing Editor.*

On motion, the report was accepted subject to the approval of the Auditing Committee.

REPORT OF THE TREASURER OF THE THOMAS SAY FOUNDATION

RECEIPTS

Balance on hand, December 21, 1937	$135.02
1938 Sales of Volume I—None.	
1938 Sales of Volume II—(15 copies)	65.25
1938 Sales of Volume III—(8 copies)	30.55
Interest on Savings Account, July 1, 1937, to June 30, 1938	2.58
Total	$233.40

EXPENDITURES

Commission on book sales—C. C. Thomas	$ 4.00
Express and postage on books	3.15
Miscellaneous postage	.90
Mailing wrappers	4.00
Total	$ 12.05
Balance in Purdue State Bank, December 15, 1938	$221.35
Total	$233.40

The Foundation has no indebtedness and has assets in the form of books (Volumes I, II and III) which represent a potential annual income of $100.00 or more, and a cash balance of $221.35. There is due $5.00 for one copy of Volume II.

Respectfully submitted,
J. J. DAVIS, *Treasurer and Editor.*

On motion, the report was accepted subject to the approval of the Auditing Committee.

REPORT OF THE AUDITING COMMITTEE

We, the undersigned members of the Auditing Committee, beg to report that we have carefully examined the accounts of the Treasurer of the Society, the Managing Editor of the ANNALS and the Treasurer of the Thomas Say Foundation for the year 1938, and have found them to be correct and properly balanced.

Respectfully submitted,
RAYMOND C. OSBURN, *Chairman,*
HOWARD O. DEAY,
A. G. RUGGLES.

On motion, the report was accepted.

REPORT OF THE NOMINATING COMMITTEE

Your Committee places in nomination the following Fellows of the Entomological Society of America, to fill the designated vacancies for the year 1939·

President—E. M. WALKER.
First Vice-President—ANN. H. MORGAN.
Second Vice-President—G. F. FERRIS.
Secretary-Treasurer—CLARENCE E. MICKEL.
Two Members of the Executive Committee to Serve Until 1941—R. E. SNODGRASS and ALFRED E. EMERSON.
Councilors to the American Association for the Advancement of Science—J. J. DAVIS and C. T. BRUES.
One Member of Joint Committee on Advancement of Official Entomology—T. J. HEADLEE.

Respectfully submitted,
H. B. HUNGERFORD, *Chairman,*
E. P. FELT,
R. N. CHAPMAN.

On motion the report was accepted and the Secretary instructed to cast a ballot for the election of the persons nominated. This being done, they were duly elected.

REPORT OF THE JOINT COMMITTEE ON INSECT COLLECTIONS, OF THE ENTOMOLOGICAL SOCIETY OF AMERICA AND THE AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

A question has been raised as to the advisability of assembling and publishing records concerning insect collections every year. Examination of the statements offered shows relatively few conspicuous additions or changes from year to year that are of general interest. It has been suggested that summaries every five years showing the status of the principal collections, institutional and private, with special comment on outstanding accessions, would be quite adequate and would have more definite and general interest for members of the two entomological societies. The Committee on Insect Collections recommends that this procedure be followed in the future.

In response to requests for data pertaining to the status of the insect collections at various institutions, with particular reference to additions and improvements made during the year 1938, the following statements have been received. In addition, those in charge of the collections at the California Academy of Sciences, University of Idaho, Iowa State College, Texas Agricultural Experiment Station and Montana State College have reported that no significant improvements or changes have occurred.

Academy of Natural Sciences, of Philadelphia, Pa.—During the year 1938 the entomological collections of the Academy have been increased by slightly over 22,000 specimens, the larger individual accessions being: 3500 Orthoptera, Hymenoptera and Diptera from Madagascar; 4,000 insects of various orders, but chiefly Lepidoptera, from the southeastern United States, taken by the Southern Florida Entomological Survey; 4,000, chiefly Orthoptera, from Mexico taken by the Third Mexican Orthoptera Expedition; 2,200 insects of various orders from Pennsylvania, New York and New Jersey, from V. S. L. Pate and John W. H. Rehn; 1,100, chiefly Odonata and Diptera, from the eastern United States, from Dr. Elizabeth G. Fisher; 1,000 Orthoptera from India, Burma and Peru, from Dr. B. Preston Clark; 950 determined Lucanidae, from John W. Angell. The expeditions or surveys specifically mentioned were official Academy activities.

The rearrangement and rehabilitation of the quarters now occupied by the Department of Insects has been continued and lighting and working facilities materially improved. Four new steel cabinets of the multiple type previously adopted as standard have been added. Extensive rearrangement work has greatly improved the determined exotic Coleoptera representation, and certain families are being installed in the new type steel cabinets. The Neuroptera series has in part been critically studied and the North American representation of certain families now embraces a very large percentage of the species known from that area.

The Academy during the year rearranged the honorary staff of the various departments and created a class of Research Fellows, placing in this, in the Department of Insects, Dr. Philip P. Calvert and Dr. Morgan Hebard, former Research Associates. The latter category had added to it, in the Department, Dr. B. Preston Clark, Dr. Emlen P. Darlington, Dr. Elizabeth G. Fisher, Dr. Frank M. Jones and Mr. V. S. L. Pate.—JAMES A. G. REHN.

American Museum of Natural History, New York, N. Y.—In addition to some special field work in Florida and Canada, the collections have, as in former years, been enriched chiefly by gifts from friends. These gifts included not only specimens but also gifts of time in helping both with the actual care of the collections and with its scientific study. Without such help the progress of this department would not be nearly so satisfactory. For our sake we regret the retirement of Mr. A. J. Mutchler but we wish him the full enjoyment of a well-earned rest.

FRANK E. LUTZ.

Buffalo Museum of Science, Buffalo, New York.—The insect collection of the Society of Natural Science at the Buffalo Museum of Science contains about 65,000 specimens of all orders, mostly acquired by purchase or donation. The

Lepidoptera and Coleoptera are best represented, especially local forms, although an unnamed collection from Cameroon, West Africa, recently donated to the Museum, includes Coleoptera, Hemiptera, Odonata and other groups. The Lepidoptera are maintained in glass-covered drawers, other insects in Schmitt boxes. Representative systematic collections of all orders are maintained for public exhibition purposes, also collections of common household pests, some of the more common moths and life history mounts. There is no permanent curator engaged, the undersigned Research Associate being in charge.—WILLIAM WILD.

University of California, Berkeley, Calif.—There is now being organized a plan for making a complete biological survey of the insect fauna of California, this to be carried out under the supervision of Professor E. O. Essig. This will mean that large numbers of insects of the state will gradually be added to the museum.

EDWIN C. VAN DYKE.

Canadian National Collection, Ottawa, Ont.—During the past year, approximately 25,000 specimens were added to the collection as a result of faunal surveys conducted by the Division of Entomology in New Brunswick, Nova Scotia, the Ottawa district, central and northern Manitoba, western Alberta, and British Columbia. Several thousand specimens, largely from western United States, were secured by exchange. A new steel cabinet containing fifty drawers was secured, and Mr. G. E. Shewell joined the staff of Systematic Entomology to assist with the collections of Diptera. Type material of 119 species was added to the collections which now contain type material of 4,441 North American species.

W. J. BROWN.

Carnegie Museum, Pittsburgh, Pa.—The more outstanding collections received in the Section of Entomology, Carnegie Museum, during 1938, are:

A highly important and valuable collection of hybrid sphingids and some other hybrid Lepidoptera acquired from Dr. H. Bytinsky-Salz of Italy. This collection contains 1,605 specimens and consists of numerous types and paratypes. A large collection of insects of different orders from Manchukuo. This collection is particularly rich in Rhopalocera and Heterocera. Lepidoptera and a few other insects gathered on Belcher Islands during Carnegie Museum Expedition there in 1938. Miscellaneous collection made in West Virginia during a six-weeks trip by our Assistant Entomologist, Mr. George E. Wallace; this material is rich in Homoptera and Chalcidoidea, the last superfamily of which Mr. Wallace makes a special study. Numerous well prepared insects, particularly Lepidoptera, from California, were presented to our collection during the year. A beautifully prepared collection of local Lepidoptera, made by the late Mr. B. Krautwurm, late preparator in our Section of Entomology, was acquired from his widow.

HUGO KAHL.

Clemson Agricultural College, Clemson, South Carolina.—The aim is to have the collections represent the entire insect fauna of this state so far as possible; naturally this has only been realized in part, and may never be entirely completed. Our showing is best in the more conspicuous groups, and in insects of good size—we are rather weak on microscopic forms generally.

To supplement the collections we maintain a card-catalogue list of all insects known to have been taken in the state, this including also records published in authentic literature. Thus our Catalogue gives a far more complete showing than the collections.

During 1938 we have made a start in transferring our identified (reference) series from Schmitt boxes to trays in glass-top cases (U. S. National Museum style), but progress is slow and the containers expensive.

Considering that we have no designated Curator and that this work is done incidentally by our various staff-members, we consider that our collections are creditable both as to extent and preservation.—FRANKLIN SHERMAN.

Colorado State College of Agriculture and Mechanical Arts, Fort Collins, Colo.—During the summer of 1938, about 10,000 pinned insects and 136 aphid slides were added to the collection. This includes a small collection of California Diptera donated to us by Mr. Charles Mitchener. The number of identified species has been increased by 300, 16 of which are represented by type material. Foreign exchanges have enabled us to build our collections of exotic Diptera, Coccinellidae, and parasitic Hymenoptera; and a donation from Dr. T. D. A. Cockerell added nine species of native and exotic bees.—M. T. JAMES.

Field Museum of Natural History, Chicago, Ill.—The collection of the Division of Insects represent principally acquisitions built up by individuals and obtained by purchase or as gifts during a period of about 44 years. The total number of specimens is approximately 173,000. Among the principal collections contained are the Herman Strecker Collection of Lepidoptera of the World, including 50,000 specimens with more than 14,000 species represented and containing nearly 800 types and cotypes; the August Sala Collection of Lepidoptera and Coleoptera (about 2,000 specimens); the E. B. Chope Collection of Coleoptera (about 10,000 specimens from the United States and Canada); G. P. Wells Collection of Coleoptera (6,000 specimens, principally from the United States and Canada); R. W. Gilbert Collection of Coleoptera (1,200 specimens principally from Michigan and Illinois); and the Henry L. Viereck Collection of Hymenoptera (about 1,200 specimens from the United States and Canada). Less than 1,000 specimens were added during 1938.

A beginning has been made to collate the various collections and house them in glass-topped drawers measuring 16x20 inches in steel cabinets. As the 504 new drawers and steel cabinets acquired last year have not yet been fully utilized, there was no need for new equipment this year.—WILLIAM J. GERHARD.

Francis Huntington Snow Entomological Museum, Lawrence, Kansas.—About 75,000 specimens have been added to the Snow Entomological Museum; 50,000 were added from the biological survey trip along the border of Mexico, from Brownsville, Texas, to San Diego, California; about 25,000 were added from South America and Mexico. 11,538 specimens have been determined, including 814 species, 313 of which were new to the collection, and 78 represented by types.

Eight steel insect cabinets were purchased, in addition to 200 wooden insect drawers.—R. H. BEAMER.

Indiana University, Bloomington, Indiana.—General Insect Collection designed for general teaching purposes. The Kinsey gall wasp collection numbers 1,500,000 bred adults and about 5,000,000 galls. About 2,000 species were represented from every continent, but chiefly from the United States, Mexico, and Guatemala. There are nearly 400 holotypes, and large paratype series. The collection is built particularly for a study of individual variation and local races, with a series of 20,000 to 100,000 individuals per species for the material that is being used for the evolutionary studies.—ALFRED C. KINSEY

Kansas State College of Agriculture and Applied Science, Manhattan, Kansas.—No outstanding acquisitions to the insect collections have been recorded, although some 6,000 insects obtained from a variety of sources were added. Definite progress has been made in rearranging the departmental and the Knaus collections and a good deal of material has been worked over by specialists and identified.

ROGER C. SMITH.

Los Angeles Museum of Sciences, History and Art, Los Angeles, Calif.—Two rooms have been added to the accommodations for the insect collections which have been growing rapidly. The largest single accession during the past year has been the Lloyd Martin collection of butterflies, comprising some 12,000 specimens. Altogether the accessions of Lepidoptera totaled 17,000 specimens or nearly half of the number of insects of all groups added to the collections, this figure being 37,384, among which virtually all the larger insect groups are represented. Accessions are tabulated by months so that it can be readily determined where material is most needed and collaborators can be informed.—W. DWIGHT PIERCE.

Massachusetts State College, Amherst, Mass.—Material determined by specialists during the past year included nearly 1,000 specimens of Hymenoptera, 1,500 Coleoptera (500 of them Elateridae), 800 Diptera, 250 Trichoptera, 400 Homoptera (Cicadellidae), 150 Neuroptera, and 150 Orthopteroids. Important additions were approximately 2,000 insects collected in the Mt. Marcy region of New York by Dr. C. P. Alexander, 750 Brazilian insects collected by Louis Pyenson, and 1,200 Pacific Coast insects presented by F. J. Spruijt. Mrs. M. E. Fernald's collection is being incorporated with the department collection, with the addition of over 1,600 named Macrolepidoptera, 250 of them new. Dr. Marion E. Smith has been appointed curator.—MARION E. SMITH.

Museum of Comparative Zoology, Cambridge, Mass.—From various gifts, purchases, and smaller expeditions we received fully 12,000 specimens. From the S. Graenicher collection about 6,000 more were added, and Dr. Darlington col-

lected over 12,000 specimens of insects, arachnids, and myriapods on his recent West Indian trip. Mr. Gaines Liu has mounted, labeled and assorted over 30,000 specimens from his Chinese collection. Mr. Liu has arranged for the Museum to keep the collection until peace is assured in China, when a set, named as far as possible, will be returned to China. Mr. Liu has worked over the Hemiptera, including our own Oriental material.

More species have been exchanged, and more determinations made, than in many years, and material has been determined and returned by outside workers in larger amount than ever before.

Types of 375 species have been catalogued since the last report; the number of insect types (species, subspecies, and varieties) catalogued now stands at 23,546; there are also over 4,000 in the Arachnida and Myriapoda.—NATHAN BANKS.

New Jersey Agricultural Experiment Station, New Brunswick, N. J.—The most important change made during the year was the relocation of the entire department in a new building. A room measuring 15 feet by 49 feet was set aside for the insect collections. This made it possible to bring all the material together into the confines of one room and also provided space for a permanent display of exhibition cases. Two new sets of steel shelving were acquired to hold the Schmitt boxes, numbering about eight hundred in all.

No large additions or other improvements occurred during the year.

JOHN B. SCHMITT.

New York State College of Agriculture at Cornell University, Ithaca, N. Y.—The chief addition to the Cornell University Insect Collections during 1938 has been the gift from Mrs. Cordt G. Rose and Mr. Charles L. Schaeffer of the undistributed balance of the Coleoptera collection of the late Charles Schaeffer. It is understood that the entire collection of the following families is included: Haliplidae, Gyrinidae, Hydrophilidae, Staphylinidae, Melyridae, Eurystethidae, Othniidae, Pedilidae, Anthicidae, Euglenidae, Helmidae, Heteroceridae, Dascillidae, Helodidae, Dermestidae, Byrrhidae, Ostomidae, Nitidulidae, Rhizophagidae, Cryptophagidae, Mycetophagidae, Lathridiidae, Mycetaeidae, Endomychidae, Alleculidae, Tenebrionidae, Lagriidae, Monommidae, Platypodidae, and Scolytidae. Six holotypes and numerous paratypes are included. Some idea of the additions made by this collection to material previously in the University Collections may be inferred from figures from two large families. In the Staphylinidae, in which the collections were previously mediocre, out of 112 genera and 408 species in the Schaeffer collection, 45 genera and 240 species were additions, while of the Tenebrionidae, previously richly represented, 31 genera and 130 species were additions.—J. CHESTER BRADLEY.

North Carolina Department of Agriculture, Raleigh, N. C.—The Insect Collection of the Entomology Division of the North Carolina Department of Agriculture contains about 7,250 species of insects nearly all from North Carolina, and approximately 100,000 specimens; these are in a little over 800 Schmitt boxes, besides a number of slides.

We added about 130 species during 1938, but there have been no changes in housing, equipment or personnel.—C. S. BRIMLEY.

Ohio State University, Columbus, Ohio.—The more outstanding accessions have been a collection of western insects by Dr. R. C. Osburn; Florida material by Dr. and Mrs. D. M. DeLong; a collection of Maine insects by Dr. D. J. Borror; light trap material from the Ohio Experiment Station; type material of species of Psyllidae by Dr. J. S. Caldwell; scale insect parasites from Dr. Paul Rice; Aphiidae slides including paratypes and parasites by C. F. Smith; Ohio material from T. H. Parks and various students, and approximately 35,000 Ohio and southwestern insects by the curator and wife.—J. N. KNULL.

Pomona College, Claremont, California.—The collection is contained in something over 1,000 Schmitt boxes and held in a special room of a fireproof building. Emphasis is placed on the local fauna and additions are made each year. The institution is little interested in assembling exotic material.—W. A. HILTON.

Utah State Agricultural College, Logan, Utah.—Approximately 30,000 pinned and microscopic-slide specimens were added to the insect collection during 1938. Significant additions were made in the orders Diptera, Lepidoptera, Orthoptera, Plecoptera, Trichoptera and Coleoptera. The greater part of the collection is now in tray system cabinet drawers. Most outstanding are the Henderson Orthoptera

collection, Knowlton aphid collection, Stanford parasite collection and Harmston collection of Dolichopodidae. Types and much duplicate named material are to be found in the U. S. National Museum and collections of various specialists who have aided with identifications. Identified material is catalogued regularly.

G. F. KNOWLTON.

University of Florida, Gainesville, Fla.—The main collection contains approximately 50,000 pinned insects, about one-half of which are determined. In addition there are some 25,000 slides of Thysanoptera and aphids, mostly determined, including the types of many species of Thysanoptera described by Prof. Watson as well as paratypes of species of aphids described by Dr. Tissot. The pinned material is housed in Schmitt boxes and has recently been moved to new fireproof quarters. There have been no significant changes in personnel nor have there been outstanding additions to the collection during the past few years.—T. H. HUBBELL.

University of Michigan, Ann Arbor, Mich.—During the year 1938 the collection has been increased by 33,160 specimens. T. H. Hubbell and J. J. Friauf collected 25,000 insects in Florida; 2,290 are from the C. L. Hubbs expedition to the Southwest; 4,100 are from Michigan including Isle Royale; and the balance, 1,770, are from various states. This brings the total number of specimens in the collection to 760,000.—ADA L. OLSON.

University of Minnesota, St. Paul, Minn.—Approximately 40,000 specimens have been added to the collection during the year. Some 10,000 specimens of this amount were acquired by gifts, the most important of which were 2,500 specimens of California insects by Dr. E. G. Anderson; 1,500 specimens of insects from Panama and Southwestern United States from Dr. R. W. Dawson and several thousand specimens of insects collected at Churchill, Manitoba, on Hudson Bay by Mr. R. H. Daggy and Mr. Donald G. Denning.

About 500 specimens of Mutillidae and 500 of Asilidae from the southwestern United States were purchased during the year.

Several thousand specimens were added to the collection in each of the following groups by graduate students and members of the staff: Trichoptera, Phyllophaga, Syrphidae, Sphecidae, Ephemerida and Scolytidae.

One hundred insect drawers and a cabinet to contain 240 such drawers were added to our equipment during the year. We have also added a cabinet for the housing of alcoholic material which doubles our capacity for storing that sort of material. The number of specimens in the collection has now passed considerably over the million mark and all groups are well represented, both in determined material and unworked material.

Material from the University collection is available to responsible students making a study of any particular group.—CLARENCE E. MICKEL.

University of Washington, Seattle, Wash.—The insect collections at the University of Washington (Seattle) consist of:

(1) Synoptic collections left to the University by O. B. Johnson who died in 1917: Coleoptera: 4,100 species, 8,300 specimens; Lepidoptera: 1,900 species, 3,600 specimens; other orders: 1,000 species, 3,000 specimens; (2) The collections of Professor Trevor Kincaid of which the Plecoptera and aquatic Hemiptera are noteworthy; (3) The Coleoptera collection of Professor Melville H. Hatch consisting of about 550 Schmitt boxes, over 10,000 species, with nearly 250 boxes of Pacific Northwest, mostly Washington State, material; (4) The Araneida collection of Dr. Harriet Exline of four or five hundred species, mostly from the State of Washington.—MELVILLE H. HATCH.

United States National Museum, Washington, D. C.—Although much needed, there has been no increase in space allotment and only the usual increment of cases and drawers for the housing of the collections. There have been no additions to the staff during this period.

The more outstanding accessions for the year were: 1,084 named specimens of Aphodiinae, containing considerable type material, from Howard E. Hinton, Cambridge, England; approximately 10,000 specimens of miscellaneous insects from Dr. David C. Graham, Szechwan, China; about 10,000 specimens of insects from Joe S. Wade, Bureau of Entomology and Plant Quarantine; approximately 54,000 miscellaneous insects received by transfer from various Government agencies, the greater part of which have come from the Bureau of Entomology and Plant Quarantine.

During the year 885 lots of type material were added to the collections; the final number in the insect series being 53,082 and the final number in the Arachnid-Milliped Catalogue 1,355.—EDWARD A. CHAPIN.

Respectfully submitted by the joint committee.

C. P. ALEXANDER, T. H. FRISON,
E. C. VAN DYKE, FRANKLIN SHERMAN,
W. J. BROWN, R. H. BEAMER,
JOSEF KNULL, C. F. W. MUESEBECK, *Chairman.*

REPORT OF THE COMMITTEE ON THE PROMOTION OF OFFICIAL ENTOMOLOGY

During the year since the last report, inquiries have been made regarding any reported reductions in appropriations for essential phases of the entomological work of the federal government. There was reported to be some danger of reductions in certain regulatory undertakings, but it also appeared that this condition was being watched and cared for by persons directly concerned. The chairman of the committee wrote a letter in support of the original appropriation for these lines of work.

The reorganization of the Department of Agriculture does not at present appear to involve danger to the entomological activities of the Department, or to indicate a disruption of the present organization. Further efforts at reorganization should, however, be carefully watched, to make sure that real damage is not done under the guise of administrative efficiency or for political expediency.

There seems to be danger to important research activities lurking in the tendency to emphasize crop control, which serves to place research activities in the background in importance. Until economic conditions are materially improved there is not much that may be done about this tendency, but when conditions improve, it will be incumbent on entomologists throughout the United States to insist upon a return to research as the method of greatest importance in the solution of the multitude of entomological problems with which the country is always faced. The recent broadening of research to include physiology and toxicology is greatly to be commended, and it cannot be too strongly insisted that there is danger to the welfare of the people of the country in any curtailment of entomological research. Problems of temporary expediency cannot with profit be permitted to overwhelm the work of greater and ultimate import.

Your present committee therefore recommends continuation of the committee and suggests that additions to its membership should be chiefly from persons geographically near enough to Washington and familiar enough with the work of the Bureau of Entomology and Plant Quarantine to assist as need be.

Respectfully submitted,

E. F. PHILLIPS, *Chairman,*
GEORGE A. DEAN,
J. J. DAVIS.

On motion, the report was accepted.

REPORT OF THE COMMITTEE ON RESOLUTIONS

1. WHEREAS, the Entomological Society of America has noted the death of the following members during the past year: FREDERICK COURTENEY GILLIATT, WILLIAM EARL RUMSEY, FREDERICK WILLIAM URICH, and ROY ALBION VICKERY,

Therefore, be it Resolved, that the Society at this, its Thirty-third Annual Meeting, express its sincere regret at the loss of these members, and order that this resolution be spread upon the minutes of this meeting and that it be printed in the ANNALS and a copy sent to the families of the deceased.

2. WHEREAS, the Thirty-third Annual Meeting of the Entomological Society of America has been made pleasant and successful largely through the efforts of the joint committee on arrangements of the Entomolgical Society of America and the American Association of Economic Entomologists,

Therefore, be it Resolved, that the thanks of the Society be extended to this joint committee, composed of MR. W. D. REED, *Chairman,* and MESSRS. W. J.

SCHOENE, P. D. SANDERS, G. T. FRENCH, H. G. WALKER, and J. W. BAILEY, for their efforts in providing the fine facilities for the conduct of these meetings.

3. WHEREAS, the Thirty-third Annual Meeting of the Entomological Society of America has been made especially enjoyable by the hospitality of the City of Richmond,

Therefore, be it Resolved, that the Society convey to the City of Richmond its deep appreciation of this hospitality.

4. WHEREAS, the officers of the Society during the past year have faithfully and successfully administered the affairs of the Society,

Therefore, be it Resolved, that the Society extend its thanks and appreciation to them for their efforts.

5. WHEREAS, DR. C. T. BRUES, of Harvard University, has ably represented the Entomological Society of America in delivering the Annual Public Address,

Therefore, be it Resolved, that the Society extend its thanks to DR. BRUES for his entertaining and instructive discourse.

6. WHEREAS, MR. BIRELY J. LANDIS has ably served the Entomological Society of America as Assistant Managing Editor of the ANNALS and has contributed notably to the excellence of style and composition of the same,

Therefore, be it Resolved, that the Society express its appreciation to MR. LANDIS for the services which he has rendered.

7. WHEREAS, DR. DORA ILSE has generously loaned for the use of the Society at the Thirty-third Annual Meeting a most interesting film on insect behavior,

Therefore, be it Resolved, that the Society express its thanks to DR. ILSE for her kindness in making this film available.

8. WHEREAS, the Entomological Society of America recognizes the tremendous importance of problems of the grasslands, and realizes the scientific value and possibilities of a large protected area for study and observation,

Therefore, be it Resolved, that the Society place itself on record as indorsing the efforts of the Ecological Society of America toward the establishment of a GRASSLANDS NATIONAL MONUMENT.

9. WHEREAS, the Hotel John Marshall has provided pleasant accommodations for our annual meeting,

Therefore, be it Resolved, that the Society express its appreciation to the management of the hotel for its excellent services.

Respectfully submitted,
C. W. SABROSKY, *Chairman*,
B. B. FULTON,
G. F. FERRIS.

On motion, the report was adopted as read.

Following the transaction of the above business, the meeting adjourned.

The following exhibits were on display in rooms near the meeting place of the Society:

1. Episodes of Insect Life. (Motion Pictures in Color.) Shown Tuesday, Wednesday and Thursday mornings at 9:00 A. M. Room to be announced. A. L. MELANDER, City College of New York, New York, New York.

2. Panama and Colombia Ant Nests. NEAL A. WEBER, University of North Dakota, Grand Forks, North Dakota.

3. Progress towards a Collection of Mallophaga from all North American Host Species. F. H. WILSON, Tulane University, New Orleans, Louisiana.

4. Mimicry in the Homoptera. Z. P. METCALF, State College Station, Raleigh, North Carolina.

5. Improvements and New Technique Used in the Study of Insects. RICHARD LEWIS POST, Ward's Natural Science Establishment, Rochester, New York.

6. A New Dermestid Found in a Nest of *Vespula arenaria* (Fab.) H. E. MILLIRON, University of Minnesota, St. Paul, Minnesota.

7. Improved Aspirator Type Insect Collector. CLYDE BARNHART, Columbus, Ohio.

Respectfully submitted,
CLARENCE E. MICKEL, *Secretary*.

BOOK NOTICES

MARVELS OF INSECT LIFE, A POPULAR ACCOUNT OF STRUCTURE AND HABITS, edited by EDWARD STEP. Pages 500, 640 figs. 7 x 9½ inches. Published by ROBERT M. MCBRIDE AND COMPANY, 116 East 16th St., New York. Price $3.75.

"Marvels of Insect Life" is a one-volume American reprint of an English two-volume work published in 1914. The phrase "edited by Edward Step" is obviously a courtesy to the many scientific men whose observations have been brought together in this very interesting account of insect life. The book is almost the last of over thirty volumes which were written by Edward Step to popularize natural history. Here one sees the methods of popularization used by a master hand with fifty years of experience in bringing to the lay reader the interesting facts of natural history.

The work is a compilation of one hundred and twenty essays on the structure and habits of insects. It is illustrated in black and white with two types of cuts, enlarged photographs of actual museum specimens and numerous full page washed drawings showing habits and habitat. The type is large and the lines are widely spaced.

Step was probably the most successful in this field of popular nature accounts of all writers in the English language. It has been interesting to the reviewer to see how he caught the interest of his reading public. Apparently his appeal was to a large class who enjoyed reading, but the members of which were not highly enough educated in science to enjoy elaborately organized works. At the same time he wrote so painstakingly with regard to scientific fact that various of his works were listed in the Zoological Record and he was awarded the high honor of a fellowship in the Linnaean Society of London. At the intermediate level which he chose, his reading public was broad enough to absorb large editions.

Some of his methods stand out in this volume: 1. The text has no formal organization. The discussion is a comfortable ramble without intellectual strain. 2. Contrast and surprise are used to keep up interest. An account of a butterfly never appears next an account of a moth or another butterfly. The next insect is more likely to be an ant or a robber fly. 3. Scientific names never obtrude. They have to be looked for (almost with a hand lens) in six-point type as foot notes. 4. Anatomical terms are avoided. A glossary of entomological terms would be wholly useless even when reading Step's account of insect anatomy. The insect is divided into three regions, "head, fore-body and hind-body." Such terms are used consistently throughout the work. 5. Only a few times is elaborate description used. In such cases as the Malayan Ornithopteras or bird-winged butterflies the author points out in some detail their remarkable, contrasty color patterns. 6. No page is without at least one three-inch-square figure. Altogether there are 640 illustrations for 120 subjects. Every fourth page is a full-page (5 x 7½ inches) washed-drawing and more often than not of insects in action. "The Mouse-catching Locust," "The Spinning Ant," "Giant Water-bug Attacking a Frog," are a few such in the first thirty pages of the work. 7. Nearly all figures are enlarged, giving the "insect-monster" type of illustration. This is particularly true of the photographs used.

We open the volume up at random. Page 256 has the black-face heading "Horned Flies." A minute footnote has the single word "Diopsidae." A page and a half of text follows telling about these flies which have their eyes on the tips of wide-spread horns. Some of the wildest Malayan genera, Giraffomyia, and Elaphomyia with orbital horns like deer or moose, are illustrated with a full page plate of four species sitting on a log in a tropical jungle. The drawings are well done even to the venation of the wings. Following next is "The Hammock Moth," and in sequence, "Insect Ichneumons" (we learn the meaning of the term Ichneumon), "The Brimstone Butterfly," "Snail-Eating Beetles," etc.

The high quality of the work in style, sound facts and in pointed illustration can be accounted for when we recall that when Edward Step died in 1931 at seventy-five years of age he had spent fifty years of his life in popularizing natural history. Apparently at no time had he let down and done hasty or superficial work. We have a list of over thirty volumes of this popular type written between

1880 and 1931. They cover all phases of outdoor natural history from birds, to native orchids, shells and insects, the inland fields and woods and the seashore. At the time of his death Step had just completed "Bees, Wasps, Ants and Allied Insects of the Wayside and Woodland."

Edward Step was born in the brick desert of London and had a grammar-school education in Holborn, one mile north of the Thames, in the very center of the greatest area of red bricks brought together anywhere in the world. His boyhood longing was apparently for green fields, singing birds and colorful butterflies. His later education was largely by private study. He was twice President of the South London Entomological and Natural History Society, was President of the British Empire Naturalist's Association and was elected a Fellow of the Linnaean Society of London. The last was a high honor for a man whose activities in later life were largely on the south side of the Thames River. It shows the respect the leading English biologists had for Edward Step's writings. The British "Who's Who," 1932, and Nature, 1931, vol. 128, p. 863, give accounts of Step and his work.

We wish to recommend this very interesting volume to all entomologists and particularly to those who are interested in the popularization of natural history. It is the product of an accomplished student and naturalist who had fifty continuous years of experience in this field.—C. H. K.

HANDBUCH DER PLANZENKRANKHEITEN. Volume 6. PFLANZENSCHUTZ. VERHUTUNG UND BEKAMPFUNG DER PFLANZENKRANKHEITEN. Herausgegeban von O. APPEL. Second part, pp. 289–576, 61 text figures, 7 × 10, paper. 1938. Published by PAUL PAREY, Berlin. Price RM. 12.45 (about $5.15).

One would not suspect from the title of this *Lieferung* of Appel's handbook of plant diseases that it contained anything on insect control or insecticides. Even the outline of contents does not make this clear, apparently Germans think in terms of plant protection whether from the attacks on plants of fungi or insects or other organisms. Actually the larger part of this book is a compilation of information on insecticides. The chief headings are as follows:

A. Physical control measures (continued and concluded).
B. Chemical control measures.
   a. Materials for plant protection.
      I. Inorganic toxicants. II. Organic toxicants. III. Accessory substances.
   b. Biological testing of materials for protection of plants and stored products.
   c. Physical and chemical testing methods.

The illustrations are limited to "A," which deals with sticky bands, barriers, mechanical disturbance, protection from frost injury, mechanical collection of insects, collection in bands or trenches, light traps, trap crops, and other kinds of traps, application of high and low temperatures, electricity, and various radiations.

Section B.a. comprises 74 per cent of the contents of this book and is concerned with insecticides, fungicides and accessory substances (e. g., spreaders). As an example of the attempt of the authors (W. Trappmann, G. Hilgendorff, A. Winkelmann, W. Fischer and W. Tomaszeuski) to cover each class of substances thoroughly, the topics under arsenicals are listed as follows: (1) History of the application of arsenicals; (2) General considerations on the application of arsenicals; (3) Toxic action of arsenicals toward (a) insects, (b) fungi, (c) plants, (d) man, (e) domestic animals, (f) soil; (4) Chemistry of arsenicals.

This reviewer knows of no other book that covers the whole field of insecticides as thoroughly as this one, and yet the space allotted to each material is so limited that no one insecticide is exhaustively treated. References to the literature are given as footnotes and on the average about one-fourth of each page is devoted to the literature cited. The book should be useful to any insecticide-minded entomologist whose German is not too rusty, although this part of volume 6 contains no index.—F. L. C.

LIFE'S BEGINNING ON THE EARTH, by R. BEUTNER, pp. VI and 222, 80 figs. 1938, 6x9 inches. Published by THE WILLIAMS AND WILKINS COMPANY, Mt. Royal and Guilford Aves., Baltimore, Md. Price, cloth, $3.00.

Dr. Beutner, who is a professor of Pharmacology at the Hahnemann Medical College and Hospital of Philadelphia, has brought together in this volume a long series of the experimental results obtained by the many investigators who have tried to reproduce living phenomena in the laboratory. This has been a subject which has always interested biologists but in recent years whole phases of this type of research (demonstration?) have been absorbed into colloid chemistry, crystallography, physiology, etc.

The text is divided into four sections: 1. The First Approach; Vital Growth and Crystallization. 2. The Second Approach; Life, Carbon's Outstanding Property. 3. The Third Approach; The Importance of Salt and Water for Life and Growth; and, 4. The Fourth Approach; The Animal a Machine.

Vital Growth and Crystallization deals with the radical changes in crystalline form which can be brought about by slight impurities and particularly impurities of a colloid nature. Here is reviewed Pfeiffer's work on blood crystallization in various diseased states. Other interesting subjects are "Network and Stripe Formation in Gelatin," "The Problem of Relation of Living Growth to Crystallization," "Presence of Crystals in Living Matter proven by X-rays."

The section on "Life, Carbon's Outstanding Property" is a sketch of organic compounds and ends with a discussion of viruses and other enzymes.

The third section on "Salt and Water" deals with the physics of life such as osmosis, movement, etc. In this section are described the curious plant-like growths which can be produced artificially from various non-living media. Stranger still are the production of "artificial cells" which will absorb (or "eat") certain artificial substances and at the end of the meal will discharge (or "defecate") the unusable waste products. Artifacts that grow and crawl about, which have been known for many years, are reviewed.

The fourth section deals with phenomena analogous to nerve impulses. In it are discussed such things as "Degeneration, poisoning, suffocation and starvation in man, animal, amoeba and in the oil-drop."

The array of anomalous simulations of living phenomena is astounding to one who has not followed the recent literature on the subject. The author is modest in merely mentioning some of his own work in which he has succeeded in constructing electric batteries of layers of fats to simulate the electric organs of certain fish.

He has merely touched upon one of the outstanding features of living matter and that is the extent and nature of the energies involved, the vast stepping up of surface energies by the minute subdivision of matter. He has dealt largely with results that are easily visible. However, it is an interesting book for those entomologists who wish to spend a few hours exploring that shadowed area between the living and the dead. The volume is well illustrated. We would have liked it even more if the author had documented his work and had given us a bibliography.

—C.H.K.

PRINCIPLES OF GENETICS, by EDMUND W. SINNOTT and L. C. DUNN, 3rd Edition, 1939. Pages XIV and 408. 147 figs., 31 tables and folded chart. 6 x 9 inches. Linen. Published by MCGRAW-HILL BOOK COMPANY, INC., 330 West 42nd St., New York, N. Y. Price $3.50.

We enjoy third editions. We have never understood why anyone wished to collect first editions. In a third or later edition every item falls into its logical place. Statements have been clarified. Poor illustrations have usually given place to better appearing ones and those used are usually more exactly tuned to the text. Many authors would help their reputations if they would publish the third edition first.

The nature of the subject helps toward clarity of presentation. Genetics is now viewed from the standpoint of the mathematician and thus much of the clear logic of that science can be followed in its exposition.

The authors catch the readers' interest with a frontispiece showing the right and left halves of the giant salivary gland chromosomes of *Drosophila melanogaster*. The halves of the larger chromosomes are figured twenty inches long. They show

the many varied bands compared directly with line charts of important gene-loci. All through the volume the greater part of the illustrations are diagrammatic in that they show in the same figure the inherited characters and, as a diagram, the proportionate inheritance of each character.

Genetics and the biological studies directly related to it have advanced so rapidly in the past few years that review works in the field of genetics open up the mechanics of living matter as no other lines of work do unless it be organic and physical chemistry. In the past ten years, or even less, have appeared great improvements in cytological methods, particularly the study of giant chromosomes and in the study of crossing over; in the use of radiation to produce mutation; in the techniques from experimental embryology such as transplantation; and in the development of statistical methods in the study of populations. These advances put good genetics texts among the most interesting biological works being published.

The volume is divided into sixteen chapters. Among the half dozen chapters on heredity, variation, Mendel's laws, linkage and crossing over which one expects in any text on heredity, occur those of broader biological interest. Some of these later developments are found in: Chap. VI. Multiple Factor Inheritance; X. Cytoplasmic Inheritance; XI. Determination of Sex; XIII. Gene Mutation; XIV. Chromosome Changes; XV. Genetics and Evolution; and XVI. Genetics and Development. These are very simple headings for the great amount of interesting material concentrated in the latter half of the volume. Chapter X gives some of the curious inheritances which appear to be evidence for cytoplasmic inheritance but may be due to masked action of nuclear material. Chapter XI is one of the best twenty-five-page reviews of sex and how it is inherited of which the reviewer has knowledge. Chapters XIII and XIV cover the remarkable work on giant chromosomes and that of the production of mutations by X-rays. Chapters XV and XVI review our present knowledge of the relationship of the genetic mechanism to populations and to evolution. The past seven years since the second edition have shown some remarkable advances in these subjects.

Each chapter has a short closely selected bibliography of recent articles and from one to five pages of problems for the student, or rather, problems for the instructor to hand out to the student, as the authors in this manner have saved the instructor many headaches in devising such.

The volume shows the excellent craftsmanship found in the McGraw-Hill text books.—C. H. K.

THE INSECT FAUNA by WILLIAM PROCTER, Part VI of the Biological Survey of the Mount Desert Region, pp. 1–496, 11 halftones, 1 map and a portrait of Charles Willison Johnson. 7x10 inches. Published by the WISTAR INSTITUTE OF ANATOMY AND BIOLOGY. Distributed privately.

To date the "Biological Survey of the Mount Desert Region" comprises six published volumes. The first, now out of print, covered the insects and was the work of C. W. Johnson. Volumes II, III and IV were in pamphlet form and were later included in vol. V. They covered the marine fauna. The present volume VI again covers "The Insect Fauna" with Dr. Procter himself as author. Except for a dozen or so pages given to a brief description of the island, the volume is a list with dates and localities of capture, of the insects and arachnids of the region. The present catalogue of insects occupies 496 pages while the list of vol. I covered only 247 pages. In Odonata, the group most familiar to the reviewer, the earlier list was of 46 species, the present list of 54 species. On looking this list over we find only one species of Somatochlora, a distinctly Canadian genus, no species of Ophiogomphus which is a genus crossing southern Canada and the northern States with a good list of eastern species. The ubiquitous *Pantala flavescens* is missing, a species we have collected north of Lake Superior. We would expect another Aeshna or two as eight or ten other species have been recorded from other parts of New England or from southeastern Canada. Obviously the dragonfly fauna is rich for so far north and has not been thoroughly collected. It takes many seasons' work and the efforts of experienced specialists to complete such a list. As far as known no competent odonatist has collected this region for one entire season.

The climate of Mount Desert Island is peculiar in its low summer temperatures and lack of winter extremes. "The highest recorded temperature during four years (on Sable Island) was 78°F. while the lowest was 5°F. above zero." Apparently

because of proximity to the ocean the humidity is high and constant. These features give a mild climate of generally low temperature. Because of such conditions the fauna and flora are unusually interesting. Two hundred and thirty arctic plants are recorded which are associated with various southern species which have spread up the coast.

The insect fauna is a similar mixture of northern species and southern, coastal species. The number is greater than in more inland faunae at this high latitude. Various students of the fauna and flora have remarked on the surprising number of species. The apparently large numbers may be due partly to the fact that so far north the cold season is long and spring, summer and fall insects tend to overlap in one shorter warm season. Identifications of species in various groups have been made by specialists, as always have to be in any catalogue of such breadth of coverage. It is a survey advantageously placed and well carried out. Inserted in the text are many notes on habits and on methods of collection.

We wish we could impress the inexperienced reader with the great amount of work involved in the necessary collecting, identification and final exacting write-up of a list of this size. Part I was published in 1927 but had back of it ten summers of work on the insects alone. Its revision in Part VI has come eleven years later.

As Doctor Procter's associations have been largely zoological in the restricted sense, a few words concerning the Director himself may interest younger entomologists. Dr. William Procter is a graduate of Yale who has had post-graduate work at Columbia, Montreal and the Sorbonne and who has finally developed his own laboratory on Mount Desert Island, Maine. He has led that dream life which we lesser minds are tempted to picture for ourselves in the shadowy lands of insomnia. After success in early life in railroad organization and the handling of railroad securities he built his own biological laboratory adjacent to the social haven of Bar Harbor. He appears to be a man torn between two abilities, that of the Procter family in the successful management of large business enterprises and that other less profitable ability in the study and analysis of nature. Because of his experience in the unusual combination of business management and of biology his services have been in wide demand as director, or as trustee, in various of the more important biological institutions. Perhaps he has been most closely associated with the Wistar Institute.—C. H. K.

TRAITÉ D'ENTOMOLOGIE MÉDICALE ET VÉTÉRINAIRE, by M. Neveu-Lemaire. Pages I–XXVII and 1–1339, 597 text figures, 6½ x 10, paper, 1938. Vigot Freres, Editeurs, 23, Rue de l'Ecole-de-Médicine, Paris. Price 250 fr. ($6.65).

One would suppose that a tome of 1339 pages might contain a very complete account of what is now known about medical and veterinary entomology. Actually it is an outline of medical and veterinary arthropodology, if one may use such a word to indicate that all arthropods, including insects, that affect the health of man and animals are considered. It is primarily a taxonomic catalogue of such arthropods. Starting with the phylum Arthropoda and defining it, the author takes up each class in turn, splitting the class into those orders, families and genera that contain species of medical and veterinary interest. The characteristics of each taxonomic subdivision are given with the derivation of the scientific name when taken from the Greek. Authors of names and synonyms are given. Keys to families and genera appear frequently. Many tables are given to facilitate identification of species within a genus. Under the name of each species is given information about its morphology, biology, and effect on man and animals. The space devoted to a species depends, of course, on its importance. Some species are dismissed with a line or two, others require several pages, but in no case do we find information approaching completeness. Nevertheless the book would be valuable for reference, if the author had cited the publications of all workers mentioned in the text. For some strange reason only a few citations are given to books and certain papers. Thus it would be difficult to run down the original literature directly from this book.

It is probably unfair to the compiler of a large book to scrutinize any small part of it through the eyes of a specialist. This reviewer having some personal knowledge of bedbugs naturally turned first to the four pages devoted to ***Cimex lectularius*** and found the account inadequate and erroneous in spots. Nothing

is said about the control of bedbugs. Two figures are given, neither of them original. Not a single citation of the literature on bedbugs is given. Consequently we are suspicious of the rest of the book, even though our sample is too small.

This book is noteworthy for the extensive treatment of the Arachnoidea, covering 350 pages, and for assembling under the common and scientific name of man and of many mammals and birds a list, arranged in taxonomic order, of all arthropods known to affect each species. With the aid of the index of scientific names and of these lists, it should be possible to find the known hosts of a given arthropod or the arthropods affecting a given host. Some consideration is also given to general entomology and to pathogenic organisms which are carried by arthropods or for which arthropods serve as intermediate hosts. Although text figures in this book are numerous, few of them are original.—F. L. C.

THE PHYLOGENY OF THE HEMIPTERA BASED ON A STUDY OF THE HEAD CAPSULE, by CHAS. S. SPOONER. 1938. No. 3 of Vol. XVI, Illinois Biological Monographs, pp. 1–102, 24 plates. Price, paper bound, $1.00.

This is a final publication of a review begun under the late Professor MacGillivray and completed recently under Professor Hayes. It covers the form of the head capsule in the greater part of the living families of the Homoptera (excepting Coccidae) and of the Heteroptera.

The author believes the Homoptera to be the older (more generalized) group. He further believes that the most primitive type of head is to be found in some genera of the Fulgoridae.

The excellencies of the volume appear to be the thorough digest of previous literature, and the excellent illustrations (398 altogether).

The reviewer feels that it is usually unsafe to draw many conclusions from a comparative study of one anatomical structure. All other checks and structures should be compared. However, the illustrations and the review of the literature will be of use to students of other anatomical parts in these groups.

The volume is up to the usual high quality of paper and presswork found in the "University of Illinois Biological Monographs."—C. H. K.

THE FAMILY POLYCTENIDAE (HEMIPTERA: HETEROPTERA) by G. F. FERRIS AND R. L. USINGER, in Microentomology, 4 (1): 1–50, 25 figs. Feb., 1939. 7 x 10 inches. Published by the Natural History Museum, Stanford University, Stanford University, Calif. Price, 75 cents.

Ever since appeared H. R. Hagen's work (The embryogeny of the Polyctenid, *Hesperoctenes fumarius* Westwood, with references to viviparity in insects, Jour. Morph. and Physiol. 51: 1–92, 1 pl., 58 figs., 1931) on the curious pseudoplacental attachment of the embryonic polyctenid to the ovarian wall of its mother, entomologists have wished to know more about these very rare parasites of bats. We have merely known that they were distantly related to bedbugs and were tropical and subtropical. We quote from the introduction:

"The bat parasites of the family Polyctenidae have received scant notice in literature because of their great rarity both in collections and, apparently, in nature. As late as 1912 it was said that the total number of specimens in museums of the world was less than two score. With the gradual accumulation of information on the group during the past seventy-five years there has emerged a general picture of the family revealing remarkable adaptations to an ectoparasitic life which are unique among Heteroptera or even among all the Insecta. The conspicuous ctenidia at once suggest the genal and other combs of the Siphonaptera while the 'pseudo-placento" viviparity is only approached among the insects by the African earwigs of the genus Hemimerus, which live as ectoparasites on rats of the genus Cricetomys. In general facies the polyctenidae are somewhat suggestive of dipterous bat parasites of the family Nycteribiidae."

The Polyctenidae may have a special copulatory organ through the lateral or dorsal body wall in the female, the organ of Berlesi, as occurs in the related Cimicidae. Sperms were found by Hagen in the female haemocoel. Some evidence exists that the female may be fertilized in a late nymphal stage. If these

strange twists in the life history of the Polyctenidae are true they constitute one of the most aberrant families of parasitic insects. The twenty-four pages of beautiful figures are by Ferris, except one in perfect Ferrisian design and finish by W. E. China, of the British Museum. The authors managed to see seventy-four specimens in the less than twenty known species.

We have cited this extremely interesting monograph partly because of the high quality of the entomology but also because it is of the best grade of offset reproduction. The m's and e's are clear and sharp. The right-hand edges are as full and straight as are the left-hand borders. The "Stanford University Press" introduced this recently developed form of publication as a partial solution of the high costs of union printing. The various blemishes inherited from the typewriter era of plain mimeograph have been overcome. Except for the open-faced type design and a grayness of the type-block, one would not notice any difference from ordinary print. Because of the minute clearance between the printing surface and the base surface of the etched metal sheet used in place of set type, a very stiff (and thus thick) sheet of paper must be used to prevent smudging in the open spaces between type lines. The very recent improvements in hardening the surface of metal plates used in etching has made this so-called off-set form of publication at all possible.

It still has disadvantages. Perfect copy and a perfect typist to produce such and to transfer perfect copy in a perfect state to the metal sheet are highly desirable.

There is little opportunity for change after the metal sheet has been typed on. Galley proof and page proof (as many as necessary) are still a strong argument for printing done by monotype and hand-set type. However, the off-set method of publication is being developed very rapidly.—C. H. K.

THE NEOTROPICAL MUTILLID WASPS OF THE GENUS TIMULLA ASHMEAD (HYMENOPTERA: MUTILLIDAE), by CLARENCE E. MICKEL. Trans. Roy. Ent. Soc. London 87 (22): 529–679, 9 pls. (135 figs.). Price £ 2-2-0.

We call attention to this monograph because it is by the Society's Secretary and because it is an example of what could be done by way of publishing larger works if more funds were available to such ends in the treasury of our Society.

This work is complementary to "The Mutillid Wasps of the Genus Timulla which occur in North America north of Mexico" (Ent. Amer. (N. S.) 17: 1–119, pls. 1–3, 1937.) The present work describes 182 species of which 112 are new to science. It is illustrated with figures of the color pattern of the female abdomen and of the last abdominal tergite of the male. The great number of new species results partly from the fact that many males could not be associated with the correct female. In many species the two sexes have had to be described under different names. Eventually as life histories become better known one such name in each pair will become a synonym. It depresses us when we see such excellent work sent abroad for publication because of lack of funds in our own treasury.—C. H. K.

THE NATURALISTS' DIRECTORY, 31ST EDITION, 1938, 227 pages. Published by THE CASINO PRESS, Salem, Mass. Price, paper bound, $3.00.

This very handy address-book needs no advertising to sell it to insect collectors and to all other entomologists who wish the present addresses of others interested in insects. It covers besides entomology, natural history in general. It specializes in addresses for North, Central and South America, but gives lists for all other parts of the world. For the European countries only a few are given. For Germany there are six; for Great Britain there are 11; for France only six. However, 227 *pages* of addresses are given altogether. These are arranged alphabetically under headings for states (U. S. A.), for provinces (Canada), and for other countries. With each address are given briefly the interests of the person listed.

Pages 216 to 221 are devoted to a list of scientific journals with subscription prices and addresses.

We are glad to see this useful address-book continued after the death of its originator. The fact that thirty-one editions have appeared is an index of its value to naturalists in general.—C. H. K.

NOTICE TO MEMBERS AND CONTRIBUTORS

The Annals of the Entomological Society of America, published by the Society quarterly, includes the Proceedings of the Annual Meetings and such papers as may be selected by the Editorial Board.

Papers may be submitted to any member of the Editorial Board and should be as nearly as possible in the form desired as final, typewritten, and illustrations finished complete ready for reproduction. Plates must not exceed 4¼x6¾ inches unless intended to fold. Cuts for illustrations are charged at cost to the author. In general, papers to be accepted must be original, complete and previously unpublished. Authors will be allowed fifty reprints gratis and additional copies at cost to the Society.

The Managing Editor is provided with the most recent address of all paid-up members on record in the Secretary's office for mailing the numbers of the Annals and members failing to receive their numbers should present their complaint to the Managing Editor within four months from the date of the mailing of the issue. After that time the numbers will be furnished only at the regular published rate.

Requests for information as to membership and annual dues of members should be sent to the Secretary-Treasurer, PROF. C. E. MICKEL, Dept. of Entomology, The Farm, University of Minnesota, Saint Paul, Minn.

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NOTICE—The Editorial Office wishes to buy a limited number of copies of Vol. XIX (1926), and of No. 3 (Sept., 1930), of Vol. XXIII; four dollars for Vol. XIX and one dollar for No. 3, Vol. XXIII.

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PRINTED IN THE UNITED STATES OF AMERICA
THE SPAHR & GLENN COMPANY, COLUMBUS, OHIO